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NUEXCO

DECEMBER 1983 NUMBER 184

Monthly Report on the Nuclear Fuel Market

NUEXCO

HEADQUARTERS

Building 3, Suite 290
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO UI)
TWX: 910-373-1760 (NUEXCO MNPK)

J. Robert Wolcott
Chairman

George White, Jr.
President

Wayne D. Fowler
Senior Vice President

Mathias M. Klingler
Chief Financial Officer

Richard K. Andersen, V.P.

Thomas A. Boyden, V.P.

R. Wesley Miller, V.P.

Christian C. Guitton

Kim P. McDonald

Donald W. Radcliffe

Judith L. Sellers

EUROPE

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

James E. Vaughan
Senior Vice President

Kathryn K. Bowen

W. Scott Hickman

NORTHEAST UNITED STATES

100 Prospect Street
Century Plaza South
Stamford, Connecticut 06901
Telephone: (203) 323-1999
Telecopy: (203) 325-1483
Telex: 4750124 (NUEXCO C)

Kenneth R. McCue, V.P.

Robert J. Alexander

Earl E. Hoellen, Jr.

Teresa Elms Lindsay

SOUTHEAST UNITED STATES

Suite 500
Seven Piedmont Center
Atlanta, Georgia 30305
Telephone: (404) 262-7375
Telecopy: (404) 233-6210
Telex: 4611142 (NUEX ATL)

M. Jerry Reaves, V.P.

James H. Allen

(See inside back cover for list of Representatives and Consultants)

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EXECUTIVE SUMMARY
REPORT 184
(All data as of November 30, 1983)

Exchange Value
$22.50, down $1.00

The **Exchange Value** is **$22.50** per pound U_3O_8, down **$1.00** since last month, the second month of decline in a row. Five uranium sales transactions are reported, involving approximately 6.2 million pounds U_3O_8. All transactions involved concentrates, and two were long-term sales of large quantities.

Supply-Demand Ratio
down slightly to 1.8:1

Active spot and near-term **uranium supply** amounts to **5.7 million** pounds U_3O_8 *equivalent,* down 0.2 million pounds from last month. Active spot and near-term **uranium demand** totals **3.1 million** pounds. The spot and near-term **supply-demand ratio** dropped slightly to **1.8:1.**

Transaction Value
rose to $23.85

The **Transaction Value** is **$23.85** per pound U_3O_8. It includes 16 transactions involving a total of 2.3 million pounds U_3O_8 equivalent and covers a period of 5 months.

Loan Use Charge Rate
unchanged at 6%

The **Loan Use Charge Rate** remains **6 percent** per annum. No loans are reported.

Conversion Value
remained at $0.60

The **Conversion Value** is **$0.60** per pound U as UF_6, unchanged since last month. No transactions are reported. Active secondary market supply of conversion services for delivery within three years totals 5.2 million pounds U as UF_6; active demand amounts to 1.3 million pounds.

SWU Values
$110 for DOE-origin (FY 84)
$90 for non-DOE origin
(delivery within 15 months)

The **SWU Values** are **$110** per SWU of DOE origin and **$90** per SWU of non-DOE origin. Eight SWU transactions are reported this month, involving a total of 3.2 million SWUs. Four of those transactions involved large amounts of non-DOE SWUs for long-term delivery. Spot and near-term supply of secondary market enrichment services amounts to 900 thousand SWUs; spot and near-term demand totals 600 thousand SWUs.

Enrichment

A slight clarification of DOE's modified ISC is likely to increase the number of 3.5-year Requirements contract holders that convert to the contract.

Argentina

Argentina is operating a gaseous diffusion enrichment plant, and a reprocessing plant is under construction.

Australia

The Australian government approved a plant that permits development of the Olympic Dam project but does not allow any other uranium projects to proceed.

China

The People's Republic of China entered into an agreement with Hongkong for construction of twin PWRs in the southern province of Guangdong.

Namibia

Nuexco's forecast of production from Namibia has been revised upwards to reflect the extension of an existing contract agreement.

Turkey

The government is considering four vendors for its planned Akkuyu unit, but construction is unlikely to begin for some time.

Basic Considerations

The first in a series of articles reviewing the basics of the nuclear fuel cycle covers separative work units (SWUs).

Forecast

Nuexco's most recent forecast of SWU consumption predicts growth from approximately 16 million SWUs in 1983 to 27 million SWUs in 1990.

Focus: West Germany

West Germany's nuclear program suffered a severe setback in the mid-1970s, but is recovering now thanks to a centrist government and an innovative construction concept, the convoy system.

Raw Materials

The uranium resource at Olympic Dam in South Australia is more than twice the size of any other known uranium resource in the world, and uranium is only a secondary mineral of the gigantic deposit.

Government Statistics

Monthly figures from January 1979 through December 1982 are listed for Australia, Canada, South Africa and the United States.

This Executive Summary may be reproduced for internal distribution.

NUEXCO REPORT 184 FIGURES OF THE MONTH (November 30, 1983)	This Month (Report 184)	Last Month (Report 183)	12 Months Ago (Report 172)
Exchange Value[1]	22.50	23.50	19.75
Transaction Value[1]	23.85	23.65	17.55
Conversion Value[2]	0.60	0.60	1.45
Loan Use Charge Rate[3]	6%	6%	6%
Near-Term Uranium Supply[4]	5.7	5.9	5.2
Near-Term Uranium Demand[5]	3.1	3.1	5.2
Near-Term Supply-Demand Ratio	1.8	1.9	1.0
Recent Uranium Sales:			
Number of Transactions[6]	5	3	9
Quantity of Material[7]	5.4-9.0	0.1-0.3	6.1-12.1
Nuexco SWU Values:[8]			
DOE origin, FY 84 delivery	110	115	
non-DOE origin, delivery within 15 months	90	85	
USDOE SWU Prices:			
AFC	138.65	138.65	138.65
Requirements	149.85	149.85	149.85
Market Value of Enriched UF_6[9] [10]:			
2.5 w/o U_{235}	625.72	653.63	693.19
3.0 w/o U_{235}	803.08	838.93	895.97
3.5 w/o U_{235}	983.72	1,027.67	1,102.91
4.0 w/o U_{235}	1,166.80	1,218.95	1,312.91

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THE URANIUM MARKET:
GRADE—NOT ALWAYS A CRUSHING EXPERIENCE

By

George White, Jr.
President
Nuexco

Presented To:

Northwest Mining Association

Spokane, Washington
December 1, 1983

THE URANIUM MARKET: GRADE—NOT ALWAYS A CRUSHING EXPERIENCE

By

George White, Jr.
President, Nuexco

Introduction

The topic of this session, "Foreign Influences on Domestic Mining," and my particular part, uranium, is an interesting and timely pairing. US production was over 43 million pounds U_3O_8 in 1980, declined to 38 million pounds in 1981, plummeted to 26 million pounds in 1982 and will drop to about 20 million pounds in 1983. And during this same period, foreign uranium producers marketed aggressively and successfully in the United States. One is liable to think, "Clearly the foreign sellers are the villains responsible for the uranium price collapse, the devastation of the US uranium industry, the US dependency on imported uranium." But this is not the case. On the contrary, and inconveniently, the big villain is much closer to home. He is none other than your friendly government, who, as usual, was only trying to help.

Historical Perspective

In the late 1960s and early 1970s, the domestic US uranium industry was in the doldrums. There was a big demand gap. Government procurement programs had ended and purchasing for the emerging nuclear power program had not yet taken up the slack. Too many uranium miners were chasing too few buyers; the competition for every order was fierce; prices were soft.

Late in 1972 and on through 1973, a number of events occurred which, when combined, were destined to send uranium prices to unheard-of heights. In no particular order of importance, four key events stand out.

1. The Arab oil embargo. This non-nuclear event spawned two subsidiary nuclear events. First, a rash of new nuclear plant orders. In the 1972-1974 period a total of 107 nuclear plants were ordered by US utilities, creating new uranium demand for nearly 150 million pounds U_3O_8 through 1983. (In those good old days we thought we could build nuclear plants in 5 or 6 years). The second subsidiary event was the legitimation of high energy prices. Oil prices rose, coal prices rose, why not uranium prices?

2. Another subtle but significant event was the now-famous short sales by Westinghouse. By taking 120 million pounds of uranium demand out of the market without effecting covering purchases, Westinghouse held back normal price development.

3. The US government, in its wisdom, reaffirmed its embargo on the use by domestic utilities of non-US origin uranium. Importation could only begin in 1977 with increasing amounts in later years.

4. Probably most importantly, the US government altered its enrichment policies. While you don't want to be overwhelmed with the technical aspects of enrichment, it is important to understand the extremely close linkage between enrichment policy and uranium demand. The key feature of the revised enrichment policy was the requirement for long-term contractual commitment (as much as 18 years in advance). Previously utilities had to give only 6 months prior notice of how much enrichment they wished to buy. The utilities, convinced that nuclear growth was going to be dramatic, and mindful of the warnings that a shortage of enrichment capacity was likely, rushed to sign these new contracts to insure enrichment supply. The key action that utilities had to take under these enrichment contracts was to deliver uranium on schedule.

Having signed up for future enrichment services, the utilities rushed out into the uranium market to contract for the uranium they were obligated to deliver under their enrichment contracts. The rest is history.

Please note that two of the four items noted above are government actions—the embargo of foreign-origin uranium and the revision of enrichment policy. Thus, government enrichment policy artificially inflated uranium demand to levels totally inconsistent with actual utility needs. The situation was aggravated by supply constrictions caused by the embargo. Small wonder that prices rose. They reached $25 per pound U_3O_8 by early fall of 1975, when they were given new impetus by the Westinghouse affair, and accelerated further, reaching $40 in early 1976. They remained over $40 through the end of 1979.

The US government inadvertently accomplished what the foreign cartel had been singularly incapable of doing —namely, an increase in uranium prices. Everyone in the US wanted to get on the gravy train. Production soared. Meanwhile, actual demand was falling. The crash was inevitable.

The Three Mile Island incident in March 1979 was a watershed event. TMI probably didn't cause anything to happen that would not have otherwise happened in time. Indeed, high interest rates, escalating costs, regulatory delays and above all low electricity growth rates had set the stage for structural changes in the nuclear industry. And while delays and cancellations had occurred prior to March 1979, it is now clear that TMI caught the attention of people in the executive suite as had no previous event. It focused concerns and catalyzed action. A trickle of deferrals and cancellations became an avalanche. Large nuclear utilities became small nuclear utilities, and small nuclear utilities packed it in completely. Non-nuclear utilities had little need for uranium. Utility inventories were liquidated into an already glutted market and prices plunged.

Despite this situation, the momentum caused by earlier events resulted in continuing increases in US production. Uranium demand was based not on what reactors needed but on a web of interlocking contracts with the enrichment contract being the linchpin. The resultant situation is illustrated in Figure 1.

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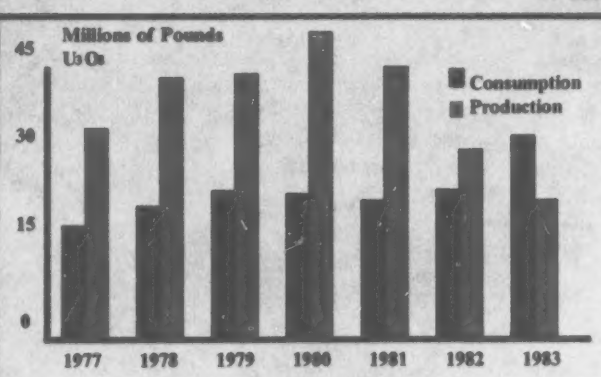

Figure 1

The astonishing thing is that in each year through 1980, production was essentially twice consumption and not until 1983 will US consumption exceed US production. Somewhere along the way we took our eyes off the target. We forgot what the utilities were actually doing—cancelling and deferring reactors. We were mesmerized by phony demand based on contracts that had nothing to do with real demand. Now we are paying the price. An enormous amount of inventory has already been liquidated, but there are still enormous quantities awaiting liquidation. It is difficult to be bullish on uranium prices while this inventory overhangs the market and production continues to exceed consumption worldwide.

Foreign Influences

The domestic uranium market is indeed subject to foreign influences, and, as the title of this paper suggests, the single most important of these influences is grade. I will have more to say about grade later, but would first note a counter-influence, namely, the unique legislative position enjoyed by US uranium miners. To my best knowledge, only uranium is protected by such congressional mandate. Specifically, the Atomic Energy Act requires the Secretary of Energy to insure the viability of the domestic uranium industry. Originally the primary means to accomplish this end was to control the amount of foreign uranium that US utilities could deliver to DOE for enrichment. 1973 regulations set this amount at zero for the years prior to 1977, 10 percent in 1977, 15 percent in 1978 increasing gradually to 80 percent in 1983 with no limit in 1984 and later. The events of the past two years have led to a new consideration of the viability of the US uranium industry, with particular emphasis on the level of foreign imports. Whether the US industry *should* or *will* be protected are separate questions which I'll discuss later.

Let me digress for another moment to identify the main foreign players. They are Canada, Australia, South Africa, Namibia, Niger, Gabon, and France. Canada is now the strongest player. While US production has declined from over 40 percent of world production to less than 15 percent, Canada's share has grown from 21 percent to 31 percent. Each of these countries, however, has its own peculiarities.

Canada essentially has two different industries, one in the east and one in the west. The old, eastern part is characterized by deep, underground, low-grade, high-cost reserves developed years ago. The new, western part, located in northern Saskatchewan, is characterized by very high-grade, relatively shallow deposits, high capital costs and low operating costs. Canadian production far exceeds the uranium needs of Canada's nuclear power program. The terms and conditions of uranium export sales are subject to government approval.

Australia has two active producers, Queensland Mines and Energy Resources of Australia (ERA). Australia's proven reserves are enormous, in excess of two billion pounds. Potential is still largely untapped. Development of a credible Australian uranium industry has been hampered by the continuing vacillation of government policy. The federal government must approve all export sales, and current policy requires floor prices which are now in excess of $30 per pound U_3O_8.

South Africa's uranium production nearly all comes as a by-product of gold mining. Production has historically been about 16 percent of the world total. Marketing is consolidated and handled by NUFCOR. Government approval is required for export sales, but government involvement is less than that found in Canada and Australia. Direct sales of U_3O_8 to US utilities are difficult due to perceived political problems. South Africa's delivery record, reliability and product quality are, however, probably the best in the world.

Namibia is the site of the Rossing mine, which annually produces nearly 10 million pounds U_3O_8. Political uncertainties will probably inhibit any further near-term development in this country, but Rossing is safe due to its importance as an earner of foreign exchange.

Niger has two operating mines and extensive additional reserves. French interests dominate, and the government is a major participant in both projects. Uranium is an important earner of foreign exchange, and, accordingly, production levels are somewhat less sensitive to prices.

Gabon is also closely tied to France, and is a relatively small producer with substantial government involvement.

France has a number of active uranium projects but is not an exporter, using all of its production to fuel an ambitious nuclear power program.

I mentioned earlier that grade was the most important foreign influence, and that can hardly be overstated. During the past four years the average grade of uranium ore mined in the US has ranged between 0.11 percent and 0.12 percent, or about 2 to 2.5 pounds U_3O_8 per ton of ore. Compare this with the two active Australian projects. The ore grade from Queensland Mines' Nabarlek mine averages over 2.36 percent. ERA's Ranger deposit has reserves in excess of 200 million pounds U_3O_8 with grade better than 0.30 percent. Or compare American ore with Saskatchewan's Key Lake deposit (2.5 percent reserves), and the multitude of other high-grade discoveries in the same geologic environment. These deposits are in remote areas and require substantial investment in in-

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frastructure, but with that kind of size and grade it is possible to build roads and towns and still be very price competitive.

It has been suggested that the US uranium industry is disadvantaged further because of strict environmental constraints imposed on it. While not an expert in this field, I must note that environmental constraints in both Australia and Saskatchewan are also strict, and if foreign producers do have an advantage in this area, it is insignificant compared to the advantages they enjoy as a consequence of size and grade.

Persistence of the US Uranium Industry

With all this emphasis on grade, size and resultant low costs, it is reasonable to ask why the current and future situation for the US uranium industry is not bleaker than we indicate. The answer is found in the nature of the utility buyer and the nature of the foreign supplier market.

First, and with respect to utilities, it must be observed that they are perhaps the most conservative business enterprises in existence. Risk aversion is a guiding policy, and risk aversion translates into concerns about security of supply. Too much, too soon may not be desirable, but it is certainly preferable to too late or too little. Source diversity is one approach to achieving security of supply, and can include multiple domestic as well as international suppliers. Price is important, but less so than security of supply.

It would be most unusual to see a US utility put all of its eggs in one foreign basket no matter what the price incentive were to do so. I know of some US utilities that have put half of their eggs in a foreign basket because of price attractions. But there are others that do not even consider foreign supply.

This may not make economic sense. The logical approach, one might reason, is for the United States to leave its low-grade, high-cost uranium in the ground as an insurance policy, and to buy low cost material from Australia, Canada and South Africa. This scenario has not and will not come to pass. US utilities will not buy 100 percent of their needs from foreign producers.

Second, note that the foreign supply market is highly concentrated. Excluding the United States, 87 percent of world production is found in four areas: Australia, Canada, Central Africa and South Africa. Each region has its own particular set of problems that lends slight unpredictability to future commitments. Furthermore, all of these foreign suppliers are bound by government involvement in the commercial aspects of the business—particularly pricing.

It is indeed ironic that only in the United States, home of low-grade, high-cost production, are producers free to do whatever they choose commercially, including going broke. Thus, we find that Cogema, the French nuclear fuel cycle company, has purchased 80 percent of Pathfinder Mines, Utah International's uranium unit. Why? With the largest percentage national commitment to nuclear power, the French are seeking diversity in the most politically stable market. And the French took this action even though they already had similar equity positions in Canada, Gabon, Niger and Namibia, and long-term supply arrangements with Australia and South Africa.

Similarly, over the past few months we have seen new interest by other overseas buyers in US uranium. It is too early to tell if these discussions will mature into definite contracts. It is my judgment, however, that these buyers are responding to the conditions that motivated Cogema.

Thus, despite its current depressed condition, reports of the death of the US uranium industry are greatly exaggerated.

Summary

At one time nuclear energy seemed to be the answer to the world's energy problems, both in the US and abroad. Suppliers of supporting products and services uncritically accepted overly optimistic forecasts; the US government's enrichment policy was a particularly important reflection of the prevailing attitude. With enrichment contracts driving demand, uranium prices soared and production expanded rapidly. Economic and regulatory constraints followed by reduced load growth led to a wave of nuclear cancellations and deferrals, particularly in the United States. Utilities liquidated their excessive uranium inventories into the market in direct competition with primary suppliers. Prices fell so low that some producers shut down operations and bought the uranium they needed to supply their long-term contracts. The price break also provided low-cost foreign sellers the opportunity to gain market share, as US producers could no longer compete economically. The US uranium industry went into a dramatic decline, marked by close-downs and wholesale withdrawals from the business.

Although current US production is only half what it was in 1980, it is a leaner industry in better shape to survive. And although the US is handicapped by higher costs and smaller orebodies, the uranium industry will survive because domestic and foreign utilities alike value the United States for its free market system and its political stability.

There is no need for an embargo to protect the US industry. The initial reasons for an embargo were weapons-related and linked to a concern that uranium was a scarce resource. We know better today. Although the grade is low, US resources are vast, and thus the only real concern is price. The near-term threat of cartel-like action by foreign suppliers (the feared UPEC) is a hollow one in a market characterized by oversupply and huge inventories.

The nuclear and uranium industries are both fully international. Interference with free market mechanisms can only be costly and disruptive. The major foreign influence, *grade*, will allow foreign penetration of the US market, but not dominance.

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

December 1983 No. 184

R. WESLEY MILLER, *EDITOR* JAMES J. LIGHTNER, *ASSISTANT EDITOR*

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To Our Readers

With this Report Nuexco introduces a new category of articles entitled *BASIC CONSIDERATIONS*. The articles presented under this category will address those readers for whom a review or an introduction to the terminology of the nuclear fuel cycle is useful. A related, specific intent of *BASIC CONSIDERATIONS* is to illustrate the effect of policies and markets of fuel cycle services on the business of natural uranium production. Because of the current emphasis on enrichment services and enriched UF_6, the first article of this series covers Separative Work Units (SWUs).

* * *

Included with this report is a copy of a speech entitled "The Uranium Market: Grade—Not Always A Crushing Experience," which Nuexco's president, Mr. George White, Jr., delivered to the Northwest Mining Association in Spokane, Washington on December 1. Reports 182 (October 1983) and 183 (November 1983) also contained speech inserts. In August, Mr. Jerry Reaves spoke at the Eighteenth Intersociety Energy Conversion Engineering Conference on "The Nuclear Fuel Cycle: Desperately In Need Of A Front End Alignment." On September 12, Nuexco's chairman, Mr. J.R. Wolcott, delivered a speech entitled "Megatrends In Nuclear Fuel: Approaching A New Era" at the Fourth Pacific Basin Nuclear Conference. In October, Mr. Donald Radcliffe presented a speech to the Society of Petroleum Engineers of AIME entitled "Another Comeback For Uranium." Also in October, at the Atomic Industrial Forum's Uranium Seminar in Santa Fe, New Mexico, Mr. George White, Jr., spoke on "The Fuelish Cycle: Markets For Excess Front-end Materials." If you did not receive a copy of one or more of these speeches with the Monthly Report, or if you would like additional copies, please contact our Menlo Park office.

* * *

Our offices will close for the Christmas holiday at noon on Friday, December 23, and will reopen on Tuesday, December 26. The offices will be closed for the New Year holiday on Monday, January 2, 1984.

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NATURAL URANIUM

The **Exchange Value** as of November 30, 1983 is **$22.50** per pound U_3O_8, down $1.00 since last month. The *Current Market Data* section of this Report lists five uranium sales, involving approximately 6.2 million pounds U_3O_8, *equivalent*. All five transactions involved concentrates; two were for long-term deliveries.

Active supply of uranium for spot and near-term delivery totals **5.7 million** pounds U_3O_8 or equivalent UF_6. **Active demand** for spot and near-term delivery totals **3.1 million** pounds U_3O_8 or equivalent UF_6. The spot and near-term **supply-demand ratio** fell slightly to **1.8:1.**

The **Transaction Value** as of November 30, 1983 is **$23.85** per pound U_3O_8, up $0.20 from last month. The current Transaction Value includes 16 transactions involving a total of 2.3 million pounds U_3O_8 or equivalent UF_6 and covers a period of 5 months.

The **Loan Use Charge Rate** as of November 30, 1983 is **6 percent** per annum, unchanged since last month in this inactive market segment.

* * *

The Exchange Value fell $1.00 during November as sellers continued their efforts to stimulate buyer activity. Nevertheless, there was little near-term buying activity. Approximately half of the uranium actively for sale in the near term is in the form of natural UF_6, while active buyers in general have indicated a preference for concentrates. Sellers of natural UF_6 are leading the market with offers below recent Exchange Values. Amounts offered in some cases are large.

Producer buying has declined substantially over the past couple of years. As a consequence, the predominant buyer market consists of utilities that do not appear motivated to buy in advance of need, even at bargain prices. Two large transactions listed in this Report involve long-term deliveries from an Australian producer to US utilities. The execution of those transactions depends on the approval of the Australian uranium export office, which is expected, and on a rise in the market price for concentrates to a level near the Australian floor price.

SECONDARY MARKET CONVERSION SERVICES

The **Conversion Value** as of November 30, 1983 is **$0.60** per pound U as UF_6, unchanged since last month. No secondary market sales of conversion services are reported this month, reflecting the lack of activity in this market. Active secondary market supply of conversion services for delivery within three years totals 5.2 million pounds U as UF_6, while the corresponding demand figure is 1.3 million pounds.

* * *

The large active supply of UF_6 in the market has altered the conditions for spot purchases of conversion services over the past few months. In October the Conversion Value fell from $1.00 to the current level of $0.60. During November the lack of market activity made it difficult to judge the Conversion Value, but it was clear that conversion services could be acquired in the secondary market for very low prices.

SECONDARY MARKET ENRICHMENT SERVICES

The secondary market **SWU Values** as of November 30, 1983 are **$110 for DOE origin** and FY 84 delivery, and **$90 for non-DOE origin** and delivery within 15 months. The Value for DOE-origin SWUs fell $5 from last month while the Value for non-DOE-origin SWUs rose $5. The *Current Market Data* section of this Report lists eight SWU transactions involving a total of approximately 3.2 million SWUs. Four of those transactions involved large amounts of non-DOE SWUs to be delivered after 1985. Active secondary market supply of enrichment services totals 885 thousand SWUs, and active demand amounts to 620 thousand SWUs.

* * *

Last month, following DOE's issuance of the modified Interim Sales Contract (ISC) to holders of 3.5-year Requirements contracts, secondary market sellers of DOE SWUs increased their offering prices sharply, to the approximate level of $115, in anticipation of increased demand from takers of the new contract. (The modified ISC permits takers to buy some SWUs of DOE origin in the secondary market without assessment of the usual termination charge). During November demand did not expand as some sellers had expected. Sellers have lowered their offering prices to the approximate level of $110 to compete for a limited number of active buyers. However, prices are likely to continue to change as potential signers of the modified ISC make decisions about the contract.

During November DOE revised the language of the modified ISC to resolve a major concern of potential takers. One of the most important terms of the contract is

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the requirement that signers later convert to the Utility Services enrichment contract (USEC) when it is issued, *if* the terms of the USEC are no less favorable than the customer's 3.5-year Requirements contract. When announced on October 18, the modified ISC did not specify who will decide, when the USEC is issued, which contract type would be more favorable to the utility. The November revision is a clear statement that the customer will make that decision.

The clarification of terms of the modified ISC should increase the number of signers significantly. At least three US utilities and one non-US utility already have indicated plans to sign an agreement with DOE in the near future. Thus far only two US utilities have signed the ISC. Philadelphia Electric signed the original version to cover all three of its units and is likely to convert to the modified ISC. Commonwealth Edison elected to cover one unit with the modified ISC. Two Japanese utilities, Tokyo Electric Power and Kansai Electric Power, have asked DOE to prepare an original ISC to cover one reactor each.

* * *

The non-DOE SWU Value rose during November because of the depletion of 1984 SWUs offered by the most active sellers. Actual sellers' offering prices vary considerably; prices for large quantities of SWUs generally fall below the current SWU Value. The longer time period for delivery of non-DOE SWUs reflects the more flexible way in which sellers of non-DOE SWUs structure their offers. During November three European utilities cancelled commitments to take a total of 1.3 million SWUs at DOE from 1986-89 in order to buy non-DOE replacement SWUs in the secondary market.

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CURRENT MARKET DATA

EXCHANGE VALUE $22.50/lb. U_3O_8
Determined as of November 30, 1983

Definition[1]

The Exchange Value is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month.

Derivation

Nuexco bases the Exchange Value upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.

Comments

Nuexco does not consider the following in determining the Exchange Value:

A. The price of uranium delivered or to be delivered under old contracts.
B. The price of uranium delivered in connection with contract renegotiations or other than arm's length transactions.

[1]In December, 1981, Nuexco published a history of the Exchange Value which chronicled, month-by-month, changes in its definition, usage and derivation. Copies are available upon request.

TRANSACTION VALUE[2]
Determined as of November 30, 1983

$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
23.85	2.3	16	5

Definition

The Transaction Value is a weighted average price of recent transactions, and is based on prices paid for U_3O_8 in transactions closed within the previous three-month period and for which delivery was scheduled within one year of the transaction date. At least ten transactions totaling at least two million pounds U_3O_8 are included in each calculation, or the sample time is extended as necessary to include these minima. Foreign currencies are converted to US dollars as of the transaction date.

Comments

Nuexco does not consider the following in determining the Transaction Value:

A. The price of uranium delivered in connection with contract renegotiations or other than arm's length transactions.
B. The price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of Exchange Value or any other independent variable. Also excluded from consideration are all data where the delivery price is defined in such a way that it cannot currently be determined.

[2]Transaction Values for 1976 through 1981 and their associated parameters (millions of pounds, number of transactions and number of months) are tabulated on pages 31 and 32 of Report 161. Corresponding data for 1982 are tabulated on page 5 of Report 173.

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CURRENT MARKET DATA

LOAN USE CHARGE RATE[1] 6%
Determined as of November 30, 1983

Definition

The Loan Use Charge Rate is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the last day of the month.

Derivation

Nuexco bases the Loan Use Charge Rate upon:

A. Data from recently completed or pending loan transactions.
B. Rates included in firm proposals to borrow or lend.
C. Rates that potential borrowers and lenders have expressed a willingness to pay or accept, but for which Nuexco is not aware of firm proposals.

[1]Monthly data for 1968 through 1981 appear on pages 32-34 of Report 162. Monthly data for 1982 appear on page 2 of Report 173.

CONVERSION VALUE[2] $0.60/lb. U as UF_6
Determined as of November 30, 1983

Definition

The Conversion Value is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the last day of the month.

Derivation

Nuexco bases the Conversion Value upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.

Comments

Nuexco does not consider the following in determining the Conversion Value:

A. The price of conversion services delivered or to be delivered under old contracts.
B. The price of conversion services delivered in connection with contract renegotiations or other than arm's length transactions.
C. Transportation charges other than those customarily provided by primary suppliers of conversion services.

[2]Monthly data for 1981 and 1982 are tabulated on page 6 of Report 173.

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SWU VALUES

$110/SWU FOR DOE ORIGIN AND FY84 DELIVERY
$90/SWU FOR NON-DOE ORIGIN AND DELIVERY WITHIN 15 MONTHS
Determined as of November 30, 1983

Definition

The SWU (Separative Work Unit) Values represent Nuexco's judgment of the prices, expressed in US dollars per SWU, at which transactions for the sale of significant quantities of SWUs of stated origins could be concluded as of the last day of the month.

Derivation

Nuexco bases the SWU Values upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.
E. SWU prices at varying tails and varying product assays are converted to the equivalent SWU price at the DOE Reference Transaction Tails Assay (presently 0.20 weight percent U_{235}) and a product assay of three percent U_{235} assuming feed costs calculated using the Nuexco Exchange Value and Nuexco Conversion Value determined as of the last day of the same month.

Comments

Nuexco does not consider the following in determining the SWU Values:

A. The price of SWUs delivered under long-term contracts from primary suppliers, such as DOE, Urenco, or Eurodif.
B. The price of SWUs delivered under other than arm's length transactions.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates	per kg U_3O_8 in Concentrates	per kg U in Concentrates
Australia (dollar)	24.68	54.40	64.15
Belgium (comm. franc)	1,236	2,725	3,214
Canada (dollar)	27.90	61.51	72.54
Finland (markka)	130.51	287.73	339.30
France (franc)	185.64	409.27	482.63
FRG (mark)	61.06	134.61	158.74
Italy (lira)	36,885	81,318	95,893
Japan (yen)	5,276	11,630	13,715
Netherlands (guilder)	68.41	150.82	177.85
South Africa (rand)	26.41	58.22	68.66
Spain (peseta)	3,507	7,731	9,117
Sweden (krona)	179.57	395.88	466.84
Switzerland (franc)	48.96	107.93	127.27
UK (pound)	15.42	34.00	40.09
US (dollar)	22.50	49.60	58.50

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates	per kg U_3O_8 in Concentrates	per kg U in Concentrates
Australia (dollar)	26.16	57.67	68.00
Belgium (comm. franc)	1,310	2,889	3,407
Canada (dollar)	29.58	65.20	76.89
Finland (markka)	138.34	304.99	359.66
France (franc)	196.78	433.83	511.59
FRG (mark)	64.72	142.69	168.26
Italy (lira)	39,098	86,197	101,647
Japan (yen)	5,592	12,328	14,538
Netherlands (guilder)	72.51	159.87	188.52
South Africa (rand)	27.99	61.71	72.78
Spain (peseta)	3,717	8,195	9,664
Sweden (krona)	190.34	419.63	494.85
Switzerland (franc)	51.89	114.40	134.91
UK (pound)	16.35	36.04	42.50
US (dollar)	23.85	52.58	62.00

[1]Calculated using currency exchange rates published in the Wall Street Journal on November 30, 1983.

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CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6	per kg U as UF_6
Australia (dollar)	0.66	1.45
Belgium (comm. franc)	32.97	72.68
Canada (dollar)	0.74	1.64
Finland (markka)	3.48	7.67
France (franc)	4.95	10.91
FRG (mark)	1.63	3.59
Italy (lira)	983.61	2,168
Japan (yen)	140.68	310.15
Netherlands (guilder)	1.82	4.02
South Africa (rand)	0.70	1.55
Spain (peseta)	93.52	206.17
Sweden (krona)	4.79	10.56
Switzerland (franc)	1.31	2.88
UK (pound)	0.41	0.91
US (dollar)	0.60	1.32

SWU VALUES EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	DOE SWU FY84	Non-DOE SWU delivery within 15 months
Australia (dollar)	120.64	98.71
Belgium (comm. franc)	6,044	4,945
Canada (dollar)	136.41	111.61
Finland (markka)	638.05	522.04
France (franc)	907.59	742.57
FRG (mark)	298.51	244.23
Italy (lira)	80,328	47,541
Japan (yen)	25,791	21,102
Netherlands (guilder)	334.45	273.64
South Africa (rand)	129.11	105.63
Spain (peseta)	17,145	14,027
Sweden (krona)	877.89	718.28
Switzerland (franc)	239.34	195.82
UK (pound)	75.39	61.69
US (dollar)	110.00	90.00

[1]Calculated using currency exchange rates published in the Wall Street Journal on November 30, 1983.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current E.V.	Seller	Buyer	Remarks
2562	1984	301-600	105	US Producer	US Utility	
2575	1985-92	3,000-5,000	indeterminate	Australian Producer	US Utility	Additional 1 million lbs. optional. Pending approval for export.
2576	1986-96	1,500-3,000	indeterminate	Australian Producer	US Utility	Option to take in 1984-85. Pending approval for export.
2583	1985	101-300	111	US Producer	US Utility	
2584	1984-85	50-100	104	US Producer	US Producer	

Secondary Market Enrichment Services

Nuexco Transaction Number	Delivery Period[2]	Approximate Quantity (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Tails Assay (Percent U_{235})	Seller Group	Buyer Group	SWU Origin	Remarks
2534	1984	50-100	85	.2	European Entity	US Utility	DOE	
2535	1984	less than 50	101	.2	European Utility	US Utility	DOE	
2549	1984-85	601-1,000	89-92	to be specified	European Entity	US Utility	Eurodif	
2570C	1986-89	301-600	indeterminate	to be specified	European Entity	European Utility	Eurodif	
2570B	1986-89	301-600	indeterminate	to be specified	European Entity	European Utility	Eurodif	
2570A	1986-89	301-600	indeterminate	to be specified	European Entity	European Utility	Eurodif	
2571	1986-89	601-1,000	indeterminate	to be specified	European Entity	European Entity	Eurodif	
2582	1984	less than 50	104	.2	European Entity	US Utility	Eurodif	

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]Refers to quarter of calendar year, not fiscal year.
[3]Price is not normalized to 0.20% tails assay.
[4]Comparison to SWU Value for same origin as SWUs included in transaction.

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CURRENT MARKET DATA

URANIUM SUPPLY
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
1575	—	500 per year	1985-92
1818	—	500 per year	1984-90
2038	2,000	—	UF_6
2134	—	250 per year	1984-87
2201	300	—	
2203	1,000	—	
2220	150	—	UF_6
2235	—	150 per year	1985-89
2236	—	200 per year	1985-89
2263	—	500 per year	1985-90
2274	—	600 per year	1985-91
2275 A	100	—	
2297	60	200 per year	1985-89
2307	340	—	UF_6
2315	170	950	UF_6
2336	250	250 per year	1985 on
2365	20	—	
2366	600	—	
2376	200	—	U_3O_8 or UF_6
2429	450	—	
TOTAL:	5,720		
INACTIVE			
2017	1,100	1,200	
2271	—	500 per year	1984-85
2191	125	—	UF_6
2193	—	800 per year	1986-90
2309	950	—	
TOTAL:	2,175		

[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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CURRENT MARKET DATA

URANIUM DEMAND
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
1459	—	200 per year	1988 on
2025	420	350	
2167	250	250 per year	1984-89
2233	700	—	U_3O_8 or UF_6
2266	450	—	
2304	—	500 per year	1987 on
2310	800	—	enriched UF_6
2313	260	255	1985
2329	—	500	1985
2357	130	—	enriched UF_6
2372	—	250 per year	1985-88
2416	—	430	
2413	—	250 per year	1986-88
2419	50	—	
TOTAL:	3,060		
INACTIVE			
1999	—	50 per year	1985-90
2118 A	250	—	
2244	—	350 per year	1985 on
2302	—	250 per year	1987 on
2360	270	—	enriched UF_6
2371	—	260 per year	1984-90 UF_6
2414	—	100 per year	1987-91 U_3O_8 or UF_6
TOTAL:	520		

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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LOAN SUPPLY AND DEMAND
(As of 10/31/83)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
1815	1,000	—	UF_6
1938	1,500	—	UF_6
2128	1,000	—	
TOTAL:	3,500		
INACTIVE			
1884	600	—	
2036	500	—	UF_6
2139	2,000	—	
TOTAL:	3,100	—	
Inquiries to Borrow:			
ACTIVE			
2118	250	—	U_3O_8 or UF_6
TOTAL:	250		

[1]Measured from the date of this Report.

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CURRENT MARKET DATA

CONVERSION SUPPLY
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
ACTIVE			
2051	1,500	—	
2141	1,500	—	
2143	200	—	
2220	210	—	
2222	80	175	
TOTAL:	3,490		
INACTIVE			
1609	1,500	—	
1936	1,500	—	
2181	1,300	650 per year	1985-90
2230	300	—	
2401	600	—	
TOTAL:	5,200		

CONVERSION DEMAND
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
ACTIVE			
2380	700	—	
2386	330	—	
2420	300	—	
TOTAL:	1,330		
INACTIVE			
2194	—	300 per year	1986 on
2287	—	250 per year	1986 on
2295	200	—	
TOTAL:	200		

[1]Measured from the date of this Report.

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SWU SUPPLY
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
1895	—	1,000	
2100	—	200	
2164	120	—	
2192	—	430	
2201	85	80	1985
2210	—	150	1985
2285	500	3,000	
2345	—	500	1985
2351	—	150 per year	1985-91
2359	180	—	
2378	—	120 per year	1985-89
2408	—	120	1985
2428	—	200	1985
TOTAL:	885		
INACTIVE			
2137	80	80 per year	1984 on
2337	250	250	
2375	200	—	
TOTAL:	530		

[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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CURRENT MARKET DATA

SWU DEMAND
(As of 11/30/83)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2233	250	—	
2272	—	200	
2282	—	300	
2310	200	—	
2355	—	180 per year	1986,88,90,92
2362	150	—	
2400	—	85	1985
2410	20	—	
2412	—	80	1985
TOTAL:	620		
INACTIVE			
2142	—	35	1985
2237	—	250 per year	1985 on
2418	—	100	1987

[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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ARGENTINA

In November the government announced that a gaseous diffusion enrichment plant near Pilcaniyeu in the southern mountain region is operating successfully. The plant, which will produce at full capacity in 1985, costed $62.5 million. Planning for it began in 1978 after the US government refused to sell Argentina enriched uranium for its research reactors. With the recent announcement an Argentine spokesman commented, "The great power's policy of not providing technology to developing countries has proved unsuccessful."

Argentina's Nuclear Energy Commission is also building a reprocessing plant that is scheduled to open in 1986. The country has had only one commercial reactor operational since 1974, Atucha 1, a 335 MWe PHWR provided by Kraftwerk Union (KWU) and located near Buenos Aires. One other government-owned unit, Embalse, a 600 MWe CANDU, reached criticality in February of this year and should begin commercial operation in 1984. The country's third unit, Atucha 2, a 692 MWe PHWR supplied by KWU, is approximately 25 percent complete and will probably be operational in the early 1990s.

AUSTRALIA

Report 183 (November 1983) lists the four main points of the Labor (ALP) government's uranium policy, which was approved in November by the ALP parliamentary caucus by a vote of 55 to 46.

1. The most important development was the approval of future uranium export from the Olympic Dam project at Roxby Downs Station in South Australia (see this Report's *Raw Materials* section).
2. No new uranium projects other than Olympic Dam may be developed.
3. Existing export contracts for Australia's two operating projects, including the two contracts recently negotiated with US utilities, will be honored, although an existing contract with a French utility will continue to be suspended for nuclear weapons-related reasons.
4. No new contracts may be approved until an inquiry by the Australian Science and Technology Council into international non-proliferation safeguards and technologies for waste disposal is concluded five months hence, in May 1984.

The ALP decision reflects a compromise between extreme Labor ideology and economic sense. A government analysis sets the maximum potential for annual contracts at approximately 3 thousand tonnes U_3O_8 for 1985-90. That level of demand, according to one official, makes Olympic Dam and other projects awaiting development "at best competitive and at worst mutually exclusive." Consequently, the potential loss of revenue associated with restricting development was outweighed by political consolation gained from the anti-uranium measures. Olympic Dam escaped the prohibition on new uranium mining mainly because its development is vital for the South Australian economy. A veto of the project would have meant the demise of the ALP in South Australia.

Nationwide, a more severe curtailment of the uranium industry than that set forth would have had serious implications for the national economy and for Australia's reputation as a trading nation. While approval for any new contracts will not be granted for at least five months, Ranger and Nabarlek may still attempt new sales. Their success in the market is largely dependent on the behavior of the spot price in relation to the Australian floor price, which is currently near the $35 level.

The Australian Labor Party is likely to remain in control of the federal government for several years, probably through 1988. No significant change in uranium policy should be expected until at least the end of the decade. Therefore, allowing for a three to four-year construction period for new mines, no uranium deliveries from any potential Australian projects should be expected before 1993. The commercial viability of the one ALP-approved project, Olympic Dam, depends most on a growth in demand for copper, which is the primary ore mineral, but an up-turn in the price of uranium is also important. Uranium from Olympic Dam probably will not be exported before the early 1990s, although sales commitments will have to be made long before then to underwrite the $1.4 billion investment.

CHINA

Recently the People's Republic of China (PRC) approved an order for two 900 MWe PWRs at Daya Bay in the southern province of Guangdong. Financing had been the major obstacle to the planned $4.5 billion twin project, which is a joint endeavor of the PRC and Hongkong. China will hold a 75 percent stake in the plant while the remainder will belong to a consortium of Hongkong interests led by China Light and Power Company. 70 percent of the power output will be sold to Hongkong. The Guangdong units, which will be supplied by Framatome, should be completed in the early 1990s.

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RECENT DEVELOPMENTS

China became a member of the International Atomic Energy Agency on October 11, 1983, four months after construction began on the 300 MWe Quinshan reactor south of Shanghai, in Zhejiang province. The PRC's first nuclear reactor, designed and built domestically, Quinshan should be completed by 1990. Shanghai is located at the mouth of the Yangtze River and is China's most populous city with more than 11 million people.

NAMIBIA

In Report 182 (October 1983) the table on page 27 illustrating Nuexco's free world uranium production forecast shows Namibia's production starting to decline in 1985, falling to 6.5 million pounds U_3O_8 in 1987 and staying at that level into the early 1990s. Published reports had indicated that the United Kingdom's Central Electricity Generating Board (CEGB) would not extend its commitment to Namibia's Rossing operation beyond an existing contract's expiration in 1984. More recent information indicates that CEGB will continue to receive uranium from Rossing for several years. The uranium production forecast for Namibia has been revised accordingly in the updated free world uranium production forecast shown in Table 1.

TURKEY

Four vendors are known to be under consideration for the planned Akkuyu unit, the future of which is nonetheless in doubt because of uncertainties about financing. General Electric, CANDU, Kraftwerk Union, and TVA have been negotiating with the Turkish government about the country's first reactor. TVA may be offering the most competitive package as it is trying to sell its deferred Yellow Creek unit, which Combustion Engineering will provide. However, KWU is thought to have placed a bid of $1.067 billion for a 970 MWE PWR, which a GE official said his company "can't beat."

The reactor order is unlikely to take place in the near future despite the interest the government is expressing to potential vendors. The recent election of a civilian government marks the beginning of a period of transition in which no significant policy decisions are likely to take place. Furthermore, the existence of a viable financing scheme is far from certain, although there are indications that KWU may include a substantial capital loan in its proposal. Even if the Akkuyu order is placed within the next year, nuclear fuel needs will not emerge until at least the end of the decade.

Table 1

FREE WORLD URANIUM PRODUCTION FORECAST
(millions of pounds U_3O_8)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Canada	20.9	24.9	32.1	31.4	31.9	31.9	31.9	31.9	31.6	31.6
United States[1]	19.7	15.0	15.3	17.1	17.2	18.2	18.3	20.9	22.5	22.3
Australia	10.5	10.5	10.5	10.5	10.5	9.2	8.0	10.0	12.8	17.6
South Africa	15.6	16.3	16.8	17.0	17.1	17.3	17.5	17.4	17.4	17.0
Namibia	9.8	10.0	10.0	10.0	8.5	8.5	8.5	8.5	8.5	8.5
Central Africa[2]	11.2	10.2	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
France	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Other Nations[3]	2.4	2.8	2.8	2.9	2.9	2.9	2.7	2.4	3.1	3.8
TOTAL FREE WORLD[4]	98	98	105	107	106	106	105	109	114	117

[1]US production forecast updated in Report 183 (November 1983).
[2]Niger and Gabon.
[3]Argentina, Belgium, Brazil, Chile, Mexico, Portugal, Spain and others.
[4]Rounded to the nearest million pounds U_3O_8. Report 182 lists the total for 1992 incorrectly as 119.

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SEPARATIVE WORK UNITS

Introduction

The manufacture of nuclear reactor fuel follows five primary steps:

1. Extraction of uranium ore;
2. Milling of ore to form natural uranium concentrates (commonly referred to as U_3O_8);
3. Conversion of concentrates to uranium hexafluoride (UF_6);
4. Enrichment of UF_6 to increase the concentration of fissionable U_{235} atoms in the product;
5. Fabrication of enriched UF_6 into solid uranium dioxide (UO_2) pellets designed to meet individual reactor core specifications.

Of these five steps, step 4, the process of enriching UF_6, is the most expensive. It involves the use of highly sophisticated equipment that, with the current technology, requires large amounts of electricity to operate. A **Separative Work Unit,** or **SWU,** is an indirect measurement of time and energy (work) used in the enrichment process.

The Enrichment Process

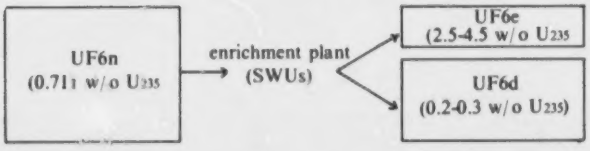
The enrichment process is schematized simply in Figure 1, which illustrates the equation:

$$UF_6n + SWUs = UF_6d + UF_6e$$

where UF_6n is *natural* UF_6 (feed), UF_6d is *depleted* UF_6 (tails), and UF_6e is *enriched* UF_6 (enriched product).

Figure 1

THE ENRICHMENT PROCESS

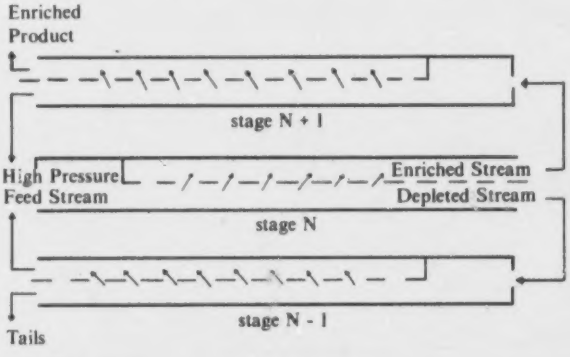


In the natural UF_6 that arrives at an enrichment plant as feed, the content of U_{235}, the fissionable light isotope of uranium, is normally 0.711 weight-percent (w/o). For most commercial applications, the enrichment process increases the U_{235} content to between 2.5 and 4.5 w/o. To achieve this higher proportion of U_{235}, enrichment processes physically separate the lighter component from the heavier components of the natural UF_6. The principal technology used to enrich the UF_6, **gaseous diffusion,** has been in use in the US for more than thirty years. Three other technologies exist, gas centrifugation, aerodynamic processes, and laser processes; several countries are developing **gas centrifugation** on a large scale.

Diffusion and centrifugation processes both separate UF_6 by exploiting the lighter atomic weight of U_{235} compared to U_{238}. The diffusion process, depicted in Figure 2, involves running the UF_6 feed at high pressure through a porous material, which allows the lighter (U_{235}) portion of the gas to escape and collect. The main portion of the feed, which becomes severely depleted of U_{235} after multiple passes through the system, is called **tails.** The small fraction of U_{235} retained in the tails is called the **tails assay** and normally falls between 0.2 and 0.3 w/o, as compared to the 0.711 w/o of the natural feed. The drawn-off portion of the UF_6, which contains a higher concentration of U_{235}, is called **enriched product.** The fraction of U_{235} in it (typically between 2.5 and 4.5 w/o for commercial applications) is called the **product assay.**

Figure 2

ENRICHMENT BY GASEOUS DIFFUSION



The centrifugation process uses less electricity per unit of output for separation of UF_6 than does the diffusion process, but the application of centrifuge technology to uranium enrichment is comparatively recent. Centrifuge technology, illustrated in Figure 3, involves the high-speed spinning of UF_6 feed to induce separation of heavy and light components. The heavier (depleted) elements in the feed are drawn by gravitational and rotational forces toward the bottom of the centrifuge, while the lighter (enriched) portion is "scooped" from the upper end of the machine.

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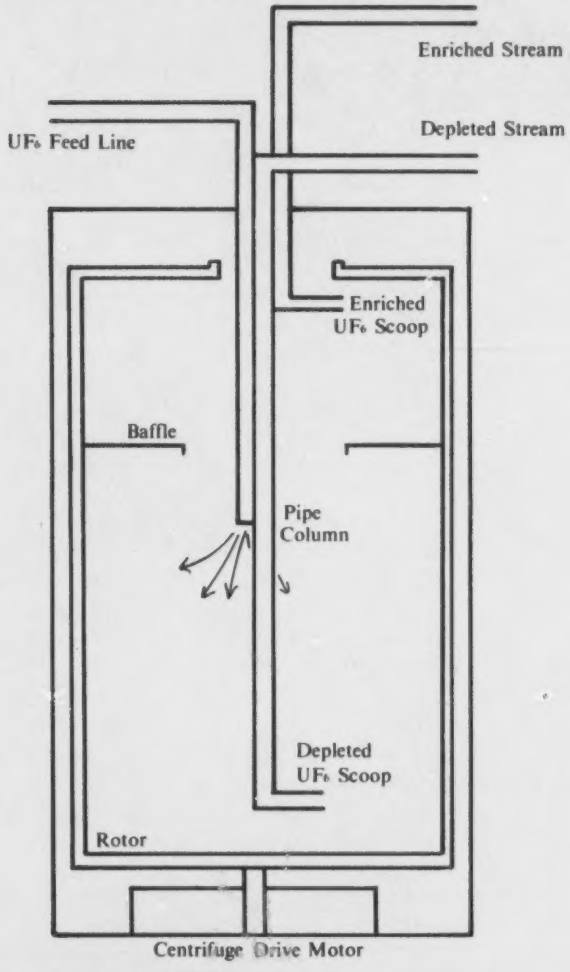
BASIC CONSIDERATIONS

Figure 3

ENRICHMENT BY GAS CENTRIFUGATION



Importance of the Tails Assay

At the end of the enrichment process the amount of depleted UF_6 (tails) greatly exceeds the amount of enriched UF_6 (enriched product); the ratio may be between 4:1 and 8:1. In general, a relatively low ratio of tails to enriched product indicates a lower tails assay (closer to 0.2 weight-percent). Therefore, for generation of a fixed quantity of enriched product, a lower tails assay requires less UF_6 feed. To achieve a lower tails assay, however, requires more SWUs. As the tails assay decreases, the number of additional SWUs necessary to draw off a given increment of U_{235} from already-depleted UF_6 increases.

An example of two enrichment alternatives illustrates the mathematics of the process and the importance of the tails assay. Assume that a utility needs to send to its fabricator 20 thousand KgU in enriched UF_6 with a product assay of 3.4 percent. In order to obtain that enriched product, the utility must buy some quantity of natural UF_6 and enrich it with some quantity of SWUs. The utility may consider several ways to achieve the same end result, two of which are depicted in Table 2.

Table 2

EFFECT OF TAILS ASSAY ON COST OF ENRICHED PRODUCT

	Alternative 1	Alternative 2
Tails Assay	0.2	0.3
UF_6 Feed @ $64/KgU	125 MtU ($8,000,000)	150 MtU ($9,600,000)
SWUs @ $138.65/SWU	105 ($14,558,250)	85 ($11,785,250)
Enriched Product	20 MtU ($22,558,250)	20 MtU ($21,385,250)
	Cost Difference = **$1,173,000**	

Alternative 1: Order a tails assay of **0.2 w/o** from the enrichment facility, supply the facility with approximately **125 thousand KgU** in natural UF_6 (325 thousand pounds U_3O_8 equivalent), and buy approximately **105 thousand SWUs.**

Alternative 2: Order a tails assay of **0.3 w/o** from the enrichment facility, supply the facility with approximately **150 thousand KgU** in natural UF_6 (390 thousand pounds U_3O_8 equivalent), and buy approximately **85 thousand SWUs.**

In either alternative, the utility meets its requirements of 20 thousand KgU in enriched product. The cost difference between the two alternatives could be quite substantial, however. The utility's choice boils down to the difference between the cost of 20 thousand SWUs and the cost of 25 thousand KgU in UF_6n. If the cost of SWUs is $138.65 per SWU (DOE price for fixed-commitment contracts) and the cost of feed is $64.00 per KgU in UF_6 (approximate market value of UF_6 as of November 1983), the cost difference between Alternative 1 and Al-

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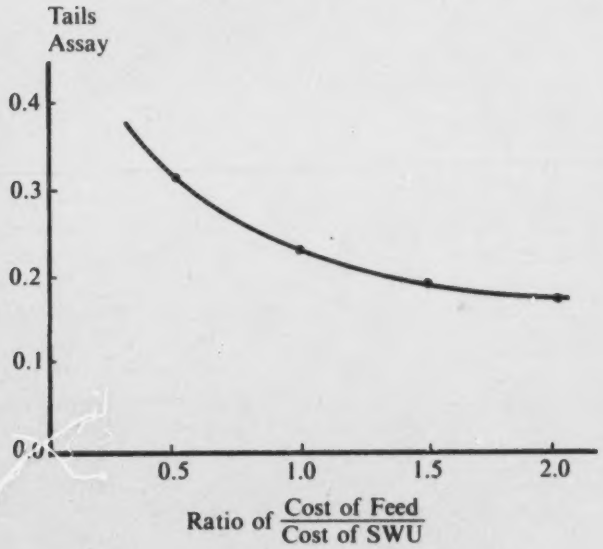
ternative 2 is (20,000 x 138.65) – (25,000 x 64.00) = $1,173,000. Alternative 2 could reduce the utility's costs by almost $1.2 million.

Most enrichment contracts do not allow utilities to choose the tails assay, but leave the designation to the enrichment supplier. When the tails assay is fixed the price of enriched product is constant. Most contract types set the tails assay near the level of 0.2 weight-percent because the lower tails reduces the accumulation of depleted UF_6 at the enrichment facility and enforces maximum SWU production for a given requirement in enriched product. One contract offered by the US Department of Energy (DOE), the Adjustable Fixed-Commitment (AFC) contract, does allow the customer to specify the tails assay in the range of 0.16-0.3 w/o. The contract provision is termed the Variable Tails Assay Option (VTAO). By exercising the VTAO, those customers with AFC contracts can obtain the **optimum tails assay,** the weight-percent in U_{235} which most reduces the cost of enriched product. Or they can adjust the tails assay to take delivery of a committed number of SWUs without excess enriched product.

Figure 4 shows the optimum tails assay curve, in which the tails assay is plotted against the ratio of the cost of UF_6 feed to the cost of SWU. As that ratio decreases, the optimum tails assay increases. In the example shown in Table 2 the ratio of feed cost to SWU cost is 0.46, so the optimum tails assay is just above 0.3 w/o.

Figure 4

OPTIMUM TAILS ASSAY CURVE



Purchase of SWUs

Currently there are four **primary market** suppliers of SWUs. Cumulatively they have the capacity to produce 42 million SWUs per year. US DOE holds most of that capacity, approximately 27 million SWUs per year. Eurodif, a joint venture among Belgium, Italy, Spain, and primarily France, has the capacity for approximately 11 million SWUs per year. Techsnabexport in the Soviet Union can export approximately 3 million SWUs per year, while Urenco, a joint venture of Britain, the Netherlands and West Germany, has the capacity to produce 1 million SWUs with modern centrifuge technology. All nuclear utilities have long-term contracts with one or more of these suppliers to meet the fuel needs of their reactors.

Utilities can also buy SWUs from other utilities in the **secondary market.** Sellers of SWUs in the secondary market usually intend to dispense with unneeded contract commitments to primary enrichers and at the same time generate cash or reduce losses. There are various means of concluding a secondary market SWU transaction. Three typical and conventional transaction types are:

1. A *sale* of enriched product, whereby the buyer pays the seller entirely with cash;
2. A *deenrichment swap,* whereby the buyer pays for enriched product by returning to the seller the equivalent UF_6 feed plus cash for the SWUs;
3. A contract *assignment,* whereby the buyer pays the seller to assume the seller's contract obligations with a primary enricher.

Secondary market sellers of SWUs often are willing to offer very competitive prices for their SWU commitments because of the strong desire to liquidate unneeded assets. Consequently, utilities that still need SWU deliveries often find attractive opportunities to cancel limited contract obligations with primary enrichers and buy replacement SWUs in the secondary market.

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ANALYSIS

FORECAST OF SWU CONSUMPTION

Introduction

Details of Nuexco's most recent forecast of Separative Work Unit (SWU) consumption are presented in Table 3. Nuexco expects consumption to increase from a total of approximately 16 million SWUs in 1983 to 27.3 million SWUs in 1990.

Methodology

The SWU consumption forecast is a theoretical calculation of the SWUs which will be consumed for the operation of commercial nuclear power reactors outside communist areas. SWU consumption is a function of nuclear electric generating capacity, as is the future consumption of U_3O_8. The SWU consumption forecast is based on the same assumptions of reactor construction and operation as the forecasts of nuclear electric generating capacity and apparent future consumption shown in Report 182 (October 1983).

Three assumptions are particularly pertinent to the SWU consumption forecast.

1. The calculation assumes an average tails assay of 0.25 weight-percent (w/o) U_{235}. Tails assays in the future will depend on the theoretical optimum tails assay, which is a function of SWU costs relative to feed costs, and on the flexibility of enrichment suppliers with regard to tails specifications.

2. CANDU heavy water reactors and English gas-cooled reactors do not currently use enriched uranium, and therefore do not consume SWUs, although CANDUs are expected to utilize low-enriched reloads in the 1990s. Some breeder reactors use enriched uranium in initial fuel loads, but are subsequently fueled by natural uranium and self-generated plutonium.

3. The calculation includes an adjustment factor to reflect inefficiency in the actual burnup of LWR fuel in comparison to the theoretical optimum. Because of fixed reload schedules, more SWUs are consumed than theoretically necessary. Units often arrive at scheduled refueling outage windows without having fully consumed core fuel. The premature discharge of fuel reduces average burnup from design levels. Fuel mechanical failures also contribute to fuel inefficiency, but are currently of minor importance, and the forecast assumes that mechanical performance will continue to improve.

Table 3

FREE WORLD SWU CONSUMPTION
(thousands of SWUs)

BUYER GROUP	1983	1984	1985	1986	1987	1988	1989	1990
United States	6,549	7,198	7,873	9,591	9,733	10,386	10,583	10,455
Europe	6,733	7,842	9,000	9,441	8,712	10,399	10,718	11,559
Far East[1]	2,497	2,891	3,434	3,497	3,716	3,545	4,655	4,718
Other Nations[2]	267	172	259	392	321	329	751	570
TOTAL FREE WORLD[3]	16,050	18,100	20,570	22,920	22,480	24,660	26,710	27,300

1. Japan, South Korea, Taiwan, Philippines.
2. Argentina, Brazil, Mexico, India, South Africa.
3. Totals rounded to nearest order of ten.

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WEST GERMANY

Introduction

The first nuclear reactor was connected to West Germany's power grid in 1961, and the national utilities pursued an active nuclear research and development program through the early 1970s. In the mid-1970s, however, the nuclear power program came to a halt following violent anti-nuclear demonstrations at the site of the Wyhl nuclear plant. After a five-year "de facto" moratorium on nuclear power construction, the nuclear industry recently has regained momentum.

Current Plan

A recent forecast indicates that electricity use will grow faster than use of any other energy form in West Germany. However, the country lacks base-load capacity for continuous low-cost generation. Germany is poor in energy resources, with significant domestic reserves only of hard coal, which is expensive to develop. As hydro and lignite have been exploited fully, nuclear power appears to be the best available alternative electricity source. A recent comparison of anticipated future costs for base-load power in France and West Germany suggests that increasing use of nuclear energy may cause substantial reductions in electricity costs. By the mid-1990s, base-load power in France, where nuclear power will represent up to 70 percent of electricity generating capacity, may cost half as much as in West Germany, where the nuclear share will represent up to 30 percent of capacity.

West Germany's Christian Democrat government wants to increase the use of nuclear power to cut energy dependence on the Soviet Block and Opec, and save low-cost lignite for synfuels development. It backs a "reasonable" buildup of nuclear power, professing a belief that safety provisions are adequate and nuclear waste problems have been solved sufficiently. Table 4 summarizes Germany's current nuclear program.

The Convoy System

The presence of six limiting factors led to the five-year de facto moratorium on nuclear plant construction in the mid-1970s.

1. A strong anti-nuclear movement;
2. Multiple federal and state licensing systems;
3. A complex, sequential licensing procedure at various steps of the construction process;
4. A lack of adequate waste storage and disposal facilities;
5. Undetermined reprocessing arrangements;
6. High vulnerability of utilities to court action.

To overcome some of the obstacles to nuclear development, Kraftwerk Union (KWU), in partnership with utilities, technical experts, and licensing authorities, developed the concept of licensing four or five standardized nuclear power stations in sequence, referred to as the "convoy" concept. KWU designed a basic 1300 MWe PWR, known as the "Construction Line 80," and established a three-step plan for installment of identical units at different sites.

1. Minimum requirements for component documentation would be clearly defined, and documents would be standardized for approval.
2. A single set of engineering documents would be valid for all projects.
3. Construction and commissioning of units would follow four steps:
   a. Construction of buildings;
   b. Mechanical and electrical component fabrication and erection;
   c. Completion of remaining site work;
   d. Loading of first core and nuclear commissioning.

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Table 4

COMMERCIAL NUCLEAR POWER STATIONS IN WEST GERMANY

Operational Reactors	Utility	Type	Output (MWe net)	Commercial Operation
Obrigheim	KWO	PWR	328	1969
Stade	NWK	PWR	630	1972
Wuergassen	PREAG	BWR	640	1972
Biblis A	RWE	PWR	1146	1975
GKN-1	GKN	PWR	810	1976
Brunsbuttel	HEW	BWR	771	1977
Biblis B	RWE	PWR	1240	1977
Unterwesser	NWK	PWR	1230	1979
KKP-1	Badenwerk/EVS	BWR	864	1980
Isar-1	Bayernwerk	BWR	870	1980
Grafenrheinfeld	Bayernwerk	PWR	1225	1982
Kruemmel	HEW	BWR	1260	1983
Total Operational (MWe net)			11,014	

Reactors Under Construction	Utility	Type	Output (MWe net)	Percent Complete	Expected Commercial Operation
KRB II Block B	RWE/Bayernwerk	BWR	1244	95	1984
THTR 300	HKG	HTR	296	90	1985
Grohnde	PREAG	PWR	1290	90	1985
KRB II Block C	RWE/Bayernwerk	BWR	1244	90	1985
KKP-2	Badenwerk/EVS	PWR	1268	90	1985
Kaerlich	RWE	PWR	1227	70	1986
SNR-300	SBK	LMFBR	295	70	1987
Brokdorf*	NWK/HEW	PWR	1290	50	1986
Isar-2*	Bayernwerk	PWR	1285	10	1988
Emsland*	VEW	PWR	1222	10	1989
GKN-2*	GKN	PWR	1230	15	1990
			11,891		

Planned Reactors					
Wyhl*	Badenwerk/EVS	PWR	1284	0	indefinite
Hamm	VEW	PWR	1300	0	indefinite
Biblis C*	RWE	PWR	1237	0	indefinite
Neupotz	RWE	PWR	1246	0	indefinite
Total Planned (MWe net)			5,067		

POSSIBLE NUCLEAR CAPACITY BY 1991	27,972

*Convoy units

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KWU expects implementation of the convoy concept to cut engineering man-hours spent on construction by 25 percent, to 2.4 million hours per 1300 MWe unit. With all engineering planning done in advance of an order, pre-planning starts only 2.5 years prior to concrete pouring. Package orders can be placed with manufacturers with resulting savings from economies of scale.

The Federal Ministry for Internal Affairs remains responsible for technical assessment of nuclear projects, while state regulatory authorities grant final construction permits. In the convoy system, documents are identical except for the site-related features of each project. Design references for one project will be accepted for other convoy units, so expert examination can concentrate on site-specific issues.

The streamlining of nuclear plant construction has been supplemented by an apparent shift in the interpretation of laws that is lessening the occurrence of purely political delays caused by nuclear opponents. Reactor design changes in the interest of greater public safety no longer require public hearings. The attitude has become prevalent that the licensing of standardized units should not be hindered by public protests and lengthy court procedures.

Nuclear Utilities

In general, West German electric power companies are private enterprises and are run as such, although in many cases local governments hold a majority of the capital stock. Each electric power company has a monopoly in its area, but the country's Energy Supply Act requires each to meet its local demand at all times. Neighboring utilities need to keep prices in line with each other because the federal government has the authority to reassign municipalities in fringe areas from one utility to another if consumer prices vary significantly.

At least twelve utilities are operating, building, or planning nuclear plants. Utility ownership of units is often interconnected, as shown in Figure 5. The government is not involved in deciding the capacities of the power stations, allowing the free market system to determine energy supplies.

Uranium Supplies

Germany does not have significant uranium deposits of its own and consequently is dependent on imports. Historically West German utilities have depended heavily on long-term contracts with commitments for five or more years. South Africa is the principal foreign supply source, providing 40 percent of 1983 deliveries and two-thirds of the long-term foreign supply. The United States accounts for only a small portion of longer term contracts, in part because of a German commitment to reprocessing and the difficulties involved with reprocessing US-origin material. A government requirement that utilities provide a waste disposal plan has led to widespread reprocessing plans. By 1992, German utilities are expected to reprocess approximately 750 thousand pounds U_3O_8 equivalent annually.

To supplement long-term contracts, German utilities enter the spot market. Often spot sales have taken the form of non-arm's-length transactions between domestic utilities or units. Utilities have also bought on the open market, particularly when they have perceived prices to be artificially low. In general the West German utilities are strong financially and have the resources to purchase low-price material and stockpile it until needed.

The utilities also are willing to lend uranium from one unit to another as well as to non-German firms. The loan or sale of material occurs between units because each of the units of one utility may have different ownerships and thus their supply and demand situations are handled differently.

West German suppliers will provide 40 percent of German utilities' 1983 uranium deliveries. Those domestic suppliers receive most of their uranium as equity owners in two projects: Ranger in Australia and Key Lake in Canada. Table 5 lists West German participation in foreign uranium production projects.

Table 5

WEST GERMAN INTERESTS IN OPERATING URANIUM PRODUCTION FACILITIES

West German Company	Project	Percent Involved	Operating Entity
Saarberg Interplan	Ranger (Australia)	3.75	ERA
Urangesellschaft	Ranger (Australia)	4.04	ERA
	Arlit (Niger)	6.50	Somair
	Rossing (Namibia)	5.00	RTZ
RWE	Ranger (Australia)	6.31	ERA
Uranerz Canada Ltd.	Key Lake (Canada)	33.30	Key Lake Mining Corp.

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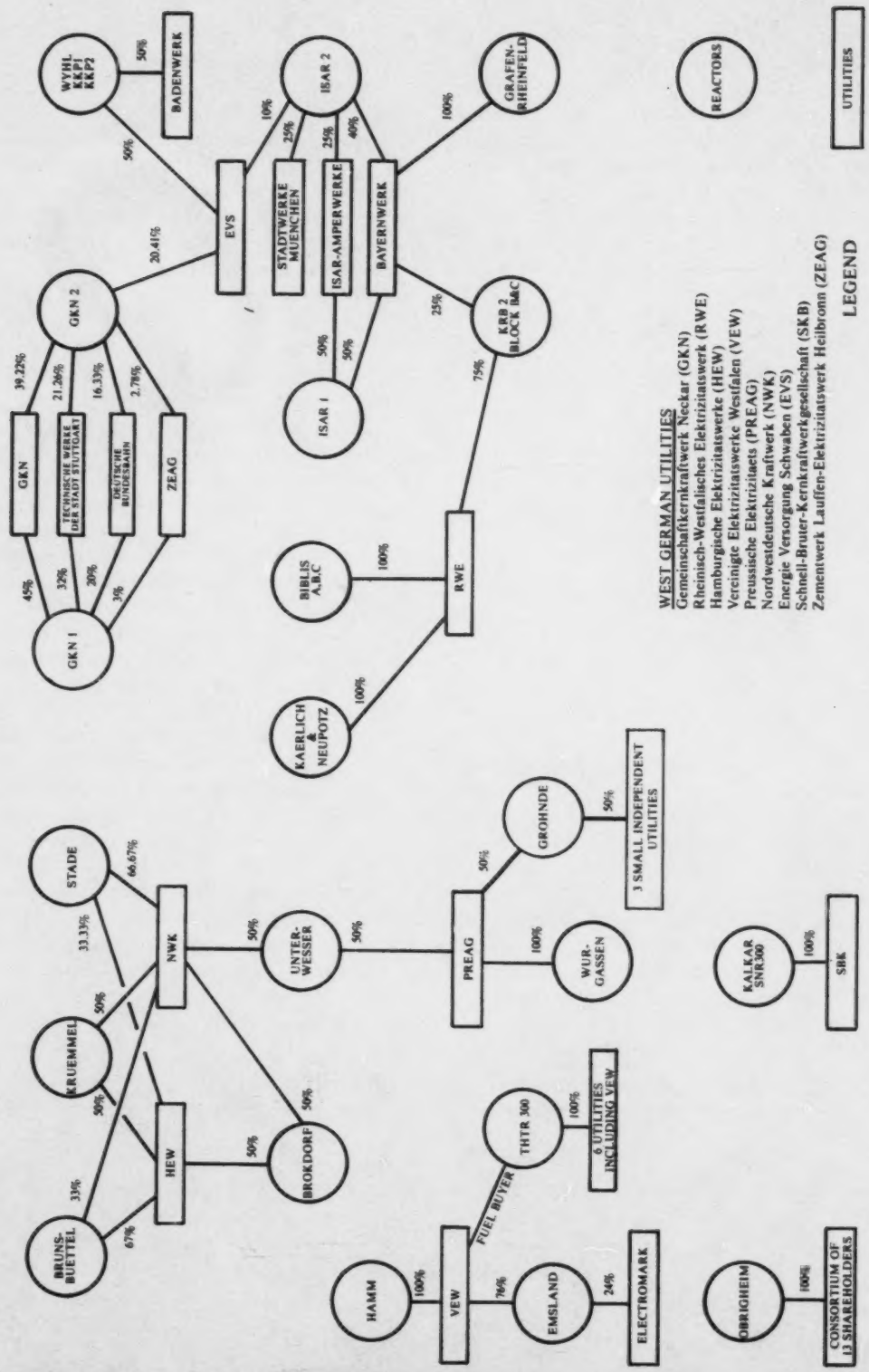

Figure 5
NUCLEAR REACTOR OWNERSHIP: WEST GERMANY

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Uranium Inventory

The West German government acquired approximately 7.4 million pounds U_3O_8 from the US in three rounds of "offset purchases," purchases made to offset the US dollar flow into West Germany associated with maintenance of US troops there. The actual amounts and forms of original purchases are listed in Table 6. The material, currently located at Urenco, is still in government hands and is used as a reserve similar to the Swedish reserve held by SKBF. West German utilities had approximately 27 million pounds U_3O_8 equivalent in inventory at the beginning of 1983. Adding the offset material to utilities' inventory results in a total national commercial uranium inventory of 34.4 million pounds U_3O_8 equivalent.

Table 6

WEST GERMAN OFFSET PURCHASES FROM THE US

Offset Number	Amount (millions of lbs. U_3O_8 equivalent)	(millions of SWUs)
1	3.56	1.1
2	0.94	0
3	2.86	0.9
TOTAL	7.36	2.0

Conversion and Enrichment

An indication of West German utilities' tendency towards diversification can be seen in their conversion and enrichment contracts. German nuclear utilities currently use Comurhex, BNFL, and Eldorado for conversion. Enrichment contracts for the 26 units listed in Table 4 include 12 with DOE, 6 with Urenco, and 5 with Techsnabexport, along with 2 additional Urenco contracts which will take effect after one DOE contract and one Techsnabexport contract expire. Table 7 lists the known US DOE enrichment contract commitments.

Nuclear Waste

Solving nuclear waste and spent fuel problems is crucial to the continuation of West Germany's nuclear power program. Utilities must present firm waste storage or disposal plans before operating permits are granted. By 1985, a generic decision will be made whether to develop domestic reprocessing or final storage facilities. Presently two intermediate storage sites are being developed, and one reprocessing plant should be operational by the mid-1990s.

The projection of close to 30,000 MWe nuclear capacity by the mid-1990s will result in an accumulation of approximately 28 million pounds of spent fuel. Under current plans, 9 million pounds will be reprocessed in France or the UK, capacity will be developed to store on-site 12 million pounds, 8 million pounds will be left at interim storage facilities, and 4 million pounds will be in reception storage at a German reprocessing plant.

Table 7

WEST GERMAN ENRICHMENT CONTRACTS WITH US DOE[1]
(thousands of SWUs)

Reactor	Utility	Contract Type	FY84	FY85	FY86	FY87	FY88	FY89
Brunsbuttel	HEW	3.5-yr Req	0	0	0	0	92	92
KKP-1	Badenwerk/EVS	3.5-yr Req	0	0	0	95	86	86
Obrigheim	KWO	3.5-yr Req	36	45	45	44	43	43
Stade	NWK	5-yr Req	37	83	86	86	86	86
THTR	HKG	5-yr Req	0	0	0	31	41	41
Wuergassen	PREAG	5-yr Req	78	0	0	0	0	0
Emsland	VEW	AFC	0	0	0	49	0	0
Grohnde	PREAG	AFC	0	134	145	145	145	145
Isar-1	Bayernwerk	AFC	66	65	0	0	0	0
KKP-1	Badenwerk/EVS	AFC	52	0	0	0	0	0
Neupotz	RWE	AFC	0	0	16	0	0	0
Unterwesser	NWK	AFC	93	0	164	164	164	165

[1]Published by DOE in September 1983.

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Summary

Comparing the total of West German utilities' supplies with Nuexco's estimate of uranium consumption (which is based in part on estimates of commercial operation dates that may vary with utility forecasts), a summary of West German utilities' uranium supply and demand situation is presented in Table 8.

Table 8

WEST GERMAN UTILITIES URANIUM INVENTORY BALANCE
(millions of pounds U_3O_8 equivalent)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Beginning Inventory[1]	31.0	33.2	30.6	30.0	30.6	27.1	24.3	23.2	21.7	20.0
plus										
Annual Supply[2]	6.2	6.1	6.9	6.1	5.5	5.7	6.2	6.2	6.1	6.1
less										
Consumption[2]	4.0	8.7	7.5	5.5	9.0	8.5	7.3	7.7	7.8	7.8
equals										
Ending Inventory	33.2	30.6	30.0	30.6	27.1	24.3	23.2	21.7	20.0	18.3
RELATIVE INVENTORY (years)[3]	4.6	4.3	4.0	4.0	3.8	3.5	3.2	3.0	2.8	2.5

[1]Nuexco estimate.
[2]Nuexco tabulation.
[3]For each year, Relative Inventory equals the number of years of forward consumption which could be supplied by that year's Beginning Inventory.

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THE OLYMPIC DAM PROJECT

Introduction

The copper-uranium-gold occurrence known as Olympic Dam is one of the world's largest known mineral deposits. The deposit is located on Roxby Downs Station about 520 km northwest of Adelaide, South Australia (Figure 6). It was discovered in July 1975 by exploration crews of Western Mining Corporation (WMC). The first hole drilled to test a geologic concept conceived by WMC, based on regional geophysical anomalies, penetrated 38 meters of copper sulfide mineralization at a depth of 353 meters. Approximately 80 percent of the 450 holes drilled on the geophysical structure indicate mineral resources that total more than two billion tonnes. The potential is excellent to increase the resource base by a significant quantity as exploration continues in the general area of interest.

Figure 6

LOCATION OF OLYMPIC DAM PROJECT ROXBY DOWNS STATION, SOUTH AUSTRALIA

That Olympic Dam is one of the world's great ore deposits is readily apparent from a recent description published by WMC[1]. According to WMC, an estimate of resources indicates the huge deposit has an average mineral content of 1.6 percent copper, 0.06 percent uranium oxide, and 0.6 grams per tonne of gold. The deposit may contain more than 30 million tonnes copper, one million tonnes uranium oxide, one million kilograms of gold, plus at least seven million kilograms of silver.

Compared directly with other world-class ore deposits, Olympic Dam's copper resource is six times larger than the Mount Isa deposit; the uranium resource is more than twice the size of any other known uranium resource in the world; the gold resource is more than twice the size of known recoverable gold resources at Driefontein in South Africa; and silver resources are larger than any other known world resource with the exception of Mount Isa. A life of at least 30 years is presently planned for the project; however, if the deposit is mined at a rate of 150,000 tonnes copper annually, project life could exceed a century.

Ownership and Development Plans

WMC announced on July 27, 1979 that an agreement in principal had been reached to conduct further project evaluation under a joint venture arrangement. Roxby Mining Corporation Pty. Ltd., a wholly-owned subsidiary of Western Mining Corporation Holdings Ltd., will retain 51 percent interest in the project; BP Australia Ltd., and BP Petroleum Development Ltd., both subsidiaries of British Petroleum (BP), will earn a 49 percent interest in the project. The terms of the agreement require BP to provide $50 million for further exploration, metallurgical testing and other work directed toward the completion of a feasibility study for commercial development of Olympic Dam.

Among other requirements and provisions of the agreement, BP is to insure funds for the development of mining and processing facilities at a production rate of up to 150,000 tonnes copper annually (at that rate, uranium production could total about 3,000 tonnes U_3O_8 annually). WMC's share of development funds are to be secured by property assets and can be repaid from the project's cash flow. Project evaluation is continuing under the direction of the Olympic Dam Joint Venturers (ODJV). Designated operator of the project is Roxby Management Services Pty. Ltd. (RMS), a wholly-owned subsidiary company of Western Mining Corporation Holdings Ltd. RMS will be the operator for the life of the project.

The ODJV entered into an indenture agreement with the government of South Australia in June 1982. The agreement established site boundaries for the mine and

[1]The Olympic Dam Project, Information Release, Aug/Sept. 1983

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processing plant and specified that special mining leases would be granted if applied for properly. In addition, the ODJV is obligated to invest at least $50 million on project evaluation, including completion of a feasibility study, between January 1, 1982 and December 31, 1984. The ODJV also is obligated to notify the state government before December 31, 1987 of any decision for further project development.

Project expenditures by the ODJV exceeded $90 million by July 1983, and $60 million has been budgeted for expenditures through December 31, 1984. Expenditures to date include the cost of an environmental impact study published in October 1982 and a supplemental study published in April 1983. Both studies were submitted to the state and commonwealth governments; approval of the environmental evaluation was granted in June 1983.

Projections of capital costs for development befit the project's overall size. The ODJV has estimated that capital costs, expressed in December 1981 Australian dollars, will be $1.4 billion (development period considered is 8 to 10 years). The cost breakdown is:

1. Mine: $300 million;
2. Metallurgical plant: $700 million;
3. Infrastructure and town: $400 million.

The government of South Australia will contribute an additional $50 million towards the cost of a new townsite required as an integral part of the project. The town will be built to accommodate a population of 9,000, with long-range planning for accommodation of up to 30,000.

Development to Date

The project currently is in the early stages of development planning. The technical aspects of mine engineering are advanced because of actual mining experience in the orebody, and orebody delineation is continuing with exploration and grid drilling. The major steps leading to commercial development will be included in the final project feasibility study due for completion by December 31, 1984.

The ODJV commissioned the sinking of an exploration shaft in 1980, designated the Whenan shaft. It was completed to a depth of 500 meters in the third quarter of 1982 (see Figure 7). Over 1.5 kms of lateral drifts have been developed off the shaft to gain access to the orebody. Exploration by underground diamond drilling has effectively aided orebody delineation. More precisely, the drilling has detailed a large, high-grade ore block readily accessible from the shaft. The ore block consists of approximately 450 million tonnes averaging 2.5 percent copper and 0.08 percent U_3O_8. For actual development conventional underground mining methods probably will be used; the thicker ore zones will be stope mined with some cut-and-fill mining where appropriate, and the thinner ore zones will be mined by room-and-piller techniques (Figure 8).

A pilot plant for development of an extractive metallurgical process will be operable in the first quarter, 1984. The ore will be crushed and fine-ground in semi-autogenous and ball mills; the sulfides will be separated by conventional flotation; the concentrates will be further processed by roasting, leaching and/or smelting. Due to the complexity of the mineral suite, pressure leaching may be a required step for maximum recovery of the uranium. Otherwise, most of the uranium will follow the flotation tailings for acidic leaching and precipitation as U_3O_8. The final product will be magnesium uranate, containing at least 70 percent U_3O_8.

The future development of the Olympic Dam deposit has been a political issue almost from the time of discovery. A controversy developed on a national scale when the copper sulfides were discovered to contain uranium. On November 7, 1983, the Labor government approved a proposal to allow the project to proceed (see *Recent Developments,* this Report).

Ore Deposit

The mineral suite at Olympic Dam includes copper, uranium, gold, silver and rare earths. Mineralization occurs in the Olympic Dam and Greenfield Formations of Proterozoic age (Precambrian). The mineralized host sequence consists of unmetamorphosed sedimentary breccias containing a variety of fine to coarse-grained rock-types, usually rich in granitic and arkosic material. The entire sequence is considered to be the upper part (over 1 km thick) of Gawler domain rocks deposited and preserved in a structural trough referred to as the Olympic Dam graben. The structure is almost 8 km in length and has a maximum width of over 4 km.

Two types of copper sulfide mineralization occur in economic concentrations in portions of the Olympic Dam and Greenfield Formations confined to the graben. Mineralization is known to occur at a depth from the surface of 343 meters to a drilled depth of 1,150 meters. The greatest concentration of mineralization is usually associated with areas of intense hematite and chlorite alteration in the four upper members of the Olympic Dam Formation; serite and silica alteration are more common in the uppermost member, and in the lower member of the Greenfield Formation. Commercial-grade sulfide

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Figure 7. Aerial photo of the Whenan shaft site. Headframe and ore storage area on the right, waste pile on the left. Roads outline a portion of the grid system utilized for exploration drilling.

Figure 8. Underground mining on the 420 meter level, Whenan shaft.

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mineralization is thus far confined to the area influenced by the graben. (Away from Olympic Dam, mineralization has been discovered at Acropolis, 25 km to the southwest, and at Wirrda Well, 20 km to the southeast; however, it is low-grade and considerably more exploration work is required to determine the economic potential in each case. Neither area is included in the Olympic Dam project.)

A brief geologic description of the mineral-bearing formations is summarized in Table 9.

Table 9

MINERALIZED FORMATIONS AT OLYMPIC DAM[1]

Geologic Age—Middle Proterozoic	Mineralized Sequence		
		Greenfield Formation	
		Volcanic Member (250 m thick)	Volcanic breccias and conglomerates
		Hematite Breccia Member (500 m thick)	Hematite-rich breccias and siltstones
	Transgressive Type	Lower Silicified Member (275 m)	Hematite and silicifed breccias, *chalcocite* and *bornite minerals*
		Olympic Dam Formation	
		Upper Granite Breccia Member (100 m thick)	Hematite-rich granite breccia, *chalcocite* and *bornite minerals*
	Strata-bound Type	Brooks Member (300 m thick)	Mixed rock breccias, brown and black hematite matrix, *chalcopyrite, bornite and chalcocite minerals*
		Whenan Member (350 m thick)	Mixed rock breccias, black and red hematite matrix, bedded units throughout, *bornite* and *chalcopyrite minerals*
		Black Hematite Member (150 m thick)	Mixed rock breccias, black hematite matrix, *chalcopyrite mineral*
		Lower Granite Breccia Member (800 m thick)	Granite and mixed rock breccias, chlorite alteration

[1]Adapted from D.E. Roberts and G.R.T. Hudson, RMS, Economic Geology, August 1983.

The most important mineralization is found in strata-bound accumulations of bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$) and chalcocite (Cu_2S) in the four upper hematite-rich (Fe_2O_3) members of the Olympic Dam Formation (see Table 9). The mineralization is uniformly disseminated throughout the matrix of the formations, making up 5 to 20 percent of the rock throughout a maximum thickness of at least 350 meters. The mineralization occurs as distinct grains in the matrix of host breccias, varying greatly in size from submicron to several centimeters. The largest particles are generally chalcopyrite and pyrite (FeS_2) intergrown with hematite in a quartz and fluorite-rich matrix. The mineralization accompanied the depositional process of the breccias. It is therefore considered to be syngenetic, being related to geothermal conditions associated with regional volcanism.

There is a distinct pattern to vertical zoning of mineralization. The sulfides tend to be sulfur-rich and copper-poor in the Black Hematite Member of the Olympic Dam Formation. Toward the top of the overlying Whenan Member and into the Brooks Member, the sulfides become copper-rich and sulfur-poor. Throughout the sequence, evidence of advanced weathering and mineral enrichment is rare; however, oxidation has been noted through the full thickness of the mineral sequence. Lateral zoning of the ore minerals has not been observed over its known length of approximately 7.5 km and maximum width of at least 4 km.

The second important occurrence of sulfide mineralization is the transgressive type consisting primarily of chalcocite and bornite sulfides confined to the Brooks Member and Upper Granite Member of the Olympic Dam Formation and the Lower Silicified Member of the Greenfield Formation. The transgressive mineralization is younger and generally overlies the strata-bound ore zone. The mineralization is confined to the central portion of the graben, extending northwest-southeast over a trend length of 7 km and a maximum width of over 2 km across two paralleling ore trends.

The minerals occur as highly disseminated grains and sulfide intergrowths, and as vein and cavity-filling material in irregular occurring lenses in a hematite-rich environment. The sulfide intergrowths vary greatly in size, but may be up to 10 centimeters across. Zoning or enrichment of mineralization has not occurred in the transgressive deposit. The ore minerals are epigenetic, having been introduced after deposition of the breccias by mineral-rich solutions migrating through the upper formations during the final stages of the first mineralizing event. Mineral concentration is limited to structurally favorable conditions within the graben. The ore deposit is age dated at 1,580 million years.

Uranium occurs disseminated throughout both types of sulfide mineralization. It is extremely fine-grained, varying from submicron to 3 millimeters in size. The

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principal ore mineral is uraninite (UO_2). The mineral coffinite [$U(SiO_4)$] occurs in close association, primarily in the more altered zones, as coatings on fractures and veins, and as discrete grains of matrix material. Brannerite [$U,Ca,Th(Ti,Fe)_2O_6$] is the third uranium mineral present, occurring almost exclusively in veins within the Brooks Member of the Olympic Dam Formation. The brannerite grains are always completely surrounded by a halo of rutile (TiO_2), forming an unusual mineral combination. Uranium deposition occurred during both phases of sulfide mineralization.

Free gold is scattered throughout both sulfide zones. The concentration is higher in the transgressive ore zone. It also occurs with hematite and is disseminated in the matrix. Silver is closely associated with gold; however, the percentage content is higher in the bornite-rich sulfide zones. It occurs as native silver and silver tellurides.

The rare earth minerals bastenite [$(Ce, La)CO_3(F,OH)$] and florencite [$CeAl_3(PO_4)_2(OH)_6$] average 0.50 percent combined rare earths. They occur primarily in association with the sulfides, but commonly with hematite and sericite alteration. The recovery of rare earths is only a minor consideration in project planning due to the low-grade nature of the occurrence.

Geology

The Olympic Dam mineral district is located in the Stuart shelf region. It is of the Australian Shield, which forms the surface rocks over large areas of South Australia. Generally, the shield areas are composed of Precambrian rocks which have been relatively stable throughout long periods of geologic time. Tectonic influence on the rock formations was for the most part limited to gentle folding and down-warping, creating broad geosynclines.

The oldest rocks in the region are included in the lower Gawler domain. They form the basement for a large part of the shield area. The rocks are Archean in age and consist of reworked gneiss, schist and intrusive rocks. Later volcanics and associated granites, age dated at about 1,500 m.y., intruded the older metamorphic sequence, as well as younger sandstones, conglomerates and volcaniclastic sediments.

Rock formations of the Stuart shelf region consist of Adelaidean sediments of late Proterozoic to Cambrian age. The sedimentary sequence is about 350 meters thick and overlies upper Gawler domain rocks—the host for the Olympic Dam deposit. The Stuart shelf is isolated from the Adelaide geosyncline to the east by a major north-south fault system referred to as the Torrens hinge zone. Geologic structure east of the hinge zone is characterized by a broad system of complex folding and faulting. This is in contrast to the more gentle structural features throughout the western part of the Stuart shelf region.

The Adelaidean sediments covering the Stuart shelf do not reflect the tectonic complexities that exist in the basement rock, primarily because of a major nonconformity that seperates the two formations. The Olympic Dam graben was revealed by drilling. The sedimentary breccias within the graben show structural displacement of more than 600 meters while paralleling faults outside the graben show displacement of up to 1200 meters.

The mineralized breccias within the graben were formed during a period of abrupt change in depositional patterns, weathering and erosion. The activity was associated with extreme tectonic activity related to development of the graben during the Kimban orogeny age dated 1,800 to 1,580 m.y. The Stuart shelf region became stable following the Kimban orogeny thereby preserving the ore deposit in the graben. There is geophysical evidence that other potentially important structures exist on the Stuart shelf, as verified by exploration successes at Acropolis and Wirrda Well. The Stuart shelf region has the geologic potential of becoming one of the largest and most prolific mineral belts of the world.

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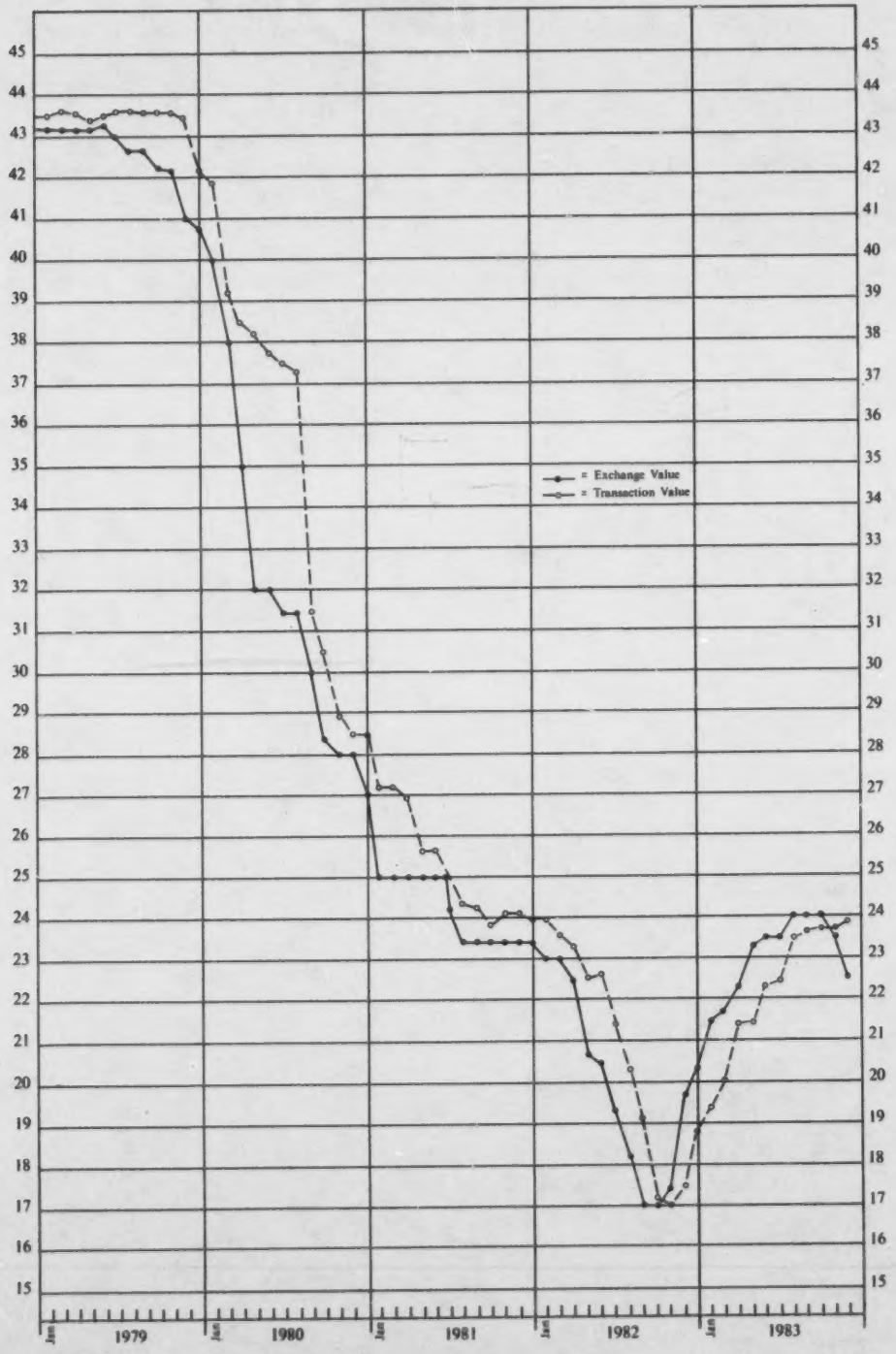
HISTORICAL MARKET DATA

EXCHANGE AND TRANSACTION VALUES
SINCE JANUARY 1979
Determined as of the last day of the month indicated



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HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	**22.50**	

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	**23.85**	

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	**0.60**	

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GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry—All Groups[1] (1969=100)	Award Rates of Pay Indexes Australia—Adult Males In Mining Wage Earners, Weekly Rates[2] (1976=100)
1972 Avg.	105.6	71.26
1973 Avg.	124.4	78.96
1974 Avg.	141.9	108.07
1975 Avg.	150.4	132.55
1976 Avg.	168.4	160.93
1977 Avg.	192.0	179.03
1978 Avg.[3] [4]	198.5	190.04
1979 Avg.	248.8	127.9R
1980 Avg.	321.8	140.8R
1981 Avg.	355.3	154.1R
1982 Avg.	368.6R	174.9R
Aug 1982	372.6R	178.2
Sep 1982	375.3R	178.4
Oct 1982	378.5R	178.4
Nov 1982	375.9R	178.5
Dec 1982	374.9R	179.5
Jan 1983	385.7R	179.6
Feb 1983	387.5R	179.5
Mar 1983	397.4R	179.4
Apr 1983	407.3R	179.7
May 1983	414.8R	179.8
Jun 1983	415.6R	179.9
Jul 1983	408.4P	179.5
Aug 1983	402.9P	179.5
Sep 1983	—	179.4P

P = Preliminary R = Revised since last month

[1]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[2]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[3]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.
[4]Annual averages prior to 1979 reflect index base no longer in use.

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AUSTRALIA: MONTHLY FIGURES 1979-1982

		Price Index of Materials Used in Manufacturing Industry—All Groups[1] (1969=100)	Award Rates of Pay Indexes Adult Males in Mining Wage Earners, Weekly Rates[2] (1976=100)
Jan	1979	246.3	123.8
Feb	1979	253.0	123.9
Mar	1979	264.0	124.5
Apr	1979	274.0	124.9
May	1979	288.5	125.5
Jun	1979	294.9	129.5
Jul	1979	298.2	129.7
Aug	1979	293.2	130.4
Sep	1979	302.4	130.8
Oct	1979	309.4	130.6
Nov	1979	310.4	130.3
Dec	1979	319.4	131.1
Jan	1980	340.1	138.6
Feb	1980	345.6	138.5
Mar	1980	340.3	138.5
Apr	1980	328.4	138.6
May	1980	335.6	138.6
Jun	1980	338.8	138.3
Jul	1980	347.8	143.1
Aug	1980	352.0	142.5
Sep	1980	350.3	142.5
Oct	1980	348.2	143.0
Nov	1980	350.4	143.2
Dec	1980	351.7	143.9
Jan	1981	357.8	149.3
Feb	1981	356.6	149.2
Mar	1981	355.2	148.9
Apr	1981	354.6	148.7
May	1981	353.4	154.0
Jun	1981	360.4	154.5
Jul	1981	357.8	154.6
Aug	1981	360.9	154.8
Sep	1981	358.4	154.8
Oct	1981	352.5	155.3
Nov	1981	351.3	157.3
Dec	1981	349.9	167.3
Jan	1982	354.9	169.3
Feb	1982	356.7	171.1
Mar	1982	360.3	171.4
Apr	1982	368.4	171.4
May	1982	368.2	171.9
Jun	1982	367.9	173.2
Jul	1982	370.1	177.2
Aug	1982	372.6	178.2
Sep	1982	375.3	178.4
Oct	1982	378.5	178.4
Nov	1982	375.9	178.5
Dec	1982	374.9	179.5

[1]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[2]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0).

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GOVERNMENT STATISTICS

CANADA

	Industry Selling Price Index: Manufacturing[1] (1971=100)	Wage-earner Data: Average Hourly Earnings (C$)[2] [3]				
		Metal Mining, including Milling[4] (SIC 050-099)	Primary Metal Industries Non-ferrous[5] (SIC 296)	(SIC 296-298)	(SIC 298)	Chemicals and Chemical Products[6] (SIC 372-379)
1979 Avg.[7]	217.9	9.66	—	7.35	—	7.67
1980 Avg.	247.2	10.80	—	8.05	—	8.50
1981 Avg.	288.7	12.23	—	9.03	—	9.53
1982 Avg.	288.8	13.92	—	9.98	—	10.63
Aug 1982	290.3	14.23	—	10.03	—	10.80
Sep 1982	292.4	14.01	—	10.18	—	10.73
Oct 1982	292.1	13.89	—	10.18	—	10.86
Nov 1982	291.3	14.28	—	10.43	—	10.90
Dec 1982	292.3	14.32	—	10.55	—	11.06
Jan 1983	292.7	14.35	—	10.72	—	11.06
Feb 1983	293.5	14.28	—	10.74	—	11.06
Mar 1983	295.2	14.48	—	10.93	—	11.21
Apr 1983	297.1	14.13	11.57	—	10.10	11.02
May 1983	298.5	14.10	11.39	—	9.82	10.97
Jun 1983	299.3R	14.07	11.33	—	9.84	11.05
Jul 1983	300.4R	13.93	11.70	—	9.83	11.04
Aug 1983	301.2R	13.89R	11.82R	—	10.08	11.19R
Sep 1983	301.0	14.15P	11.96P	—	10.28P	11.19P
Oct 1983	301.7P	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Beginning with the April 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to April 1983 only companies employing fewer than 200 wage earners are included in the Wage Earner Data.

[4]The wage earner series in Nuexco reports prior to March 1983 was "Metals" (SIC 050-059).

[5]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[6]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[7]Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

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CANADA: MONTHLY FIGURES 1979-1982

	Industry Selling Price Index: Manufacturing (1971 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]		
		Metal Mining, including Milling (SIC 050-099)	Primary Metal Industries Non-ferrous (SIC 296-298)	Chemicals and Chemical Products (SIC 370-379)
Jan 1979	204.8	9.30	7.14	7.29
Feb 1979	208.5	9.40	7.18	7.36
Mar 1979	210.4	9.48	7.20	7.51
Apr 1979	212.8	9.60	7.26	7.63
May 1979	214.5	9.56	7.28	7.61
Jun 1979	216.0	9.51	7.27	7.66
Jul 1979	218.3	9.45	7.34	7.73
Aug 1979	220.0	9.60	7.38	7.77
Sep 1979	223.4	9.82	7.50	7.81
Oct 1979	227.4	10.03	7.54	7.88
Nov 1979	228.1	10.11	7.61	7.91
Dec 1979	230.4	10.05	7.51	7.89
Jan 1980	239.0	10.26	7.57	7.99
Feb 1980	240.8	10.38	7.69	8.08
Mar 1980	239.5	10.59	7.83	8.26
Apr 1980	241.1	10.54	7.94	8.36
May 1980	242.4	10.64	8.01	8.44
Jun 1980	243.7	10.67	8.07	8.46
Jul 1980	246.3	10.69	8.11	8.55
Aug 1980	249.4	10.74	8.14	8.65
Sep 1980	252.0	11.00	8.24	8.71
Oct 1980	256.0	11.29	8.28	8.82
Nov 1980	257.8	11.42	8.38	8.77
Dec 1980	258.4	11.43	8.32	8.92
Jan 1981	263.3	11.58	8.51	8.90
Feb 1981	263.7	11.73	8.59	9.00
Mar 1981	265.5	11.76	8.63	9.17
Apr 1981	267.9	11.93	8.76	9.33
May 1981	270.0	11.99	8.90	9.49
Jun 1981	272.3	12.03	9.16	9.57
Jul 1981	274.3	12.07	9.20	9.62
Aug 1981	276.2	12.19	9.15	9.63
Sep 1981	276.9	12.63	9.22	9.77
Oct 1981	279.3	12.82	9.35	9.91
Nov 1981	278.8	13.01	9.45	9.89
Dec 1981	280.0	12.96	9.42	10.03
Jan 1982	281.9	13.49	9.53	10.11
Feb 1982	283.5	13.61	9.60	10.19
Mar 1982	284.8	13.74	9.62	10.35
Apr 1982	287.7	13.81	9.79	10.48
May 1982	288.8	13.86	9.88	10.62
Jun 1982	289.7	13.83	9.92	10.69
Jul 1982	290.3	14.02	10.05	10.73
Aug 1982	290.3	14.23	10.03	10.80
Sep 1982	292.4	14.01	10.18	10.73
Oct 1982	292.1	13.89	10.18	10.86
Nov 1982	291.3	14.28	10.43	10.90
Dec 1982	292.3	14.32	10.55	11.06

[1]Statistics Canada, [illegible] Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011).
[2]Statistics Canada, [illegible] Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

	Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Consumer Price Index[2] (1975 = 100)[3]	Producer Price Index All Groups[4] (1975=100)	Total Employment in Mining and Quarrying (Code 35)[5]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[5]
1972 Avg.	8.79	113.3	63.9	623,067	443,933
1973 Avg.	10.51	124.1	72.3	684,743	572,133
1974 Avg.	13.18	138.5	85.3	674,140	761,596
1975 Avg.	16.71	157.2	100.0	639,473	1,003,617
1976 Avg.	19.30	174.7	115.1	671,240	1,212,983
1977 Avg.	23.87	194.4	130.0	712,006	1,420,670
1978 Avg.	27.14	137.2	142.7	664,571	1,537,169
1979 Avg.[6]	30.18	155.3	164.5	692,209	1,830,632
1980 Avg.[7]	35.53	176.7	192.1	714,379	2,279,615
1981 Avg.	41.89	206.5	218.3	728,506	2,820,505
1982 Avg.	47.25	233.5	248.7	707,552	3,246,071
May 1982	—	230.3	244.8	715,162	258,770
Jun 1982	45.77	232.1	246.7	707,552	261,361
Jul 1982	—	234.1	249.4	702,141	283,248
Aug 1982	—	236.8	253.4	705,562	276,730
Sep 1982	48.04	241.0	255.0	704,344	282,782
Oct 1982	—	243.9	260.1	701,316	285,328
Nov 1982	—	245.4	262.5	707,966	287,699
Dec 1982	49.62	246.2	263.0	683,982	288,019
Jan 1983	—	249.0	264.9	688,030	289,075
Feb 1983	—	253.1	267.4	697,089	281,413
Mar 1983	50.35	255.9	269.1	695,976	290,586
Apr 1983	—	257.8	270.9	697,158	286,708
May 1983	—	259.7	274.1	701,712	295,701
Jun 1983	50.51	260.8	273.1	706,933	300,177
Jul 1983	—	262.5	273.7	704,202	314,566
Aug 1983	—	265.6	278.9	698,984	311,789
Sep 1983	52.92	267.3	279.4	—	—
Oct 1983	—	270.0	—	—	—

[1]Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly. The tonnage-weight index of average working costs per metric ton of gold ore milled for 1983 follows. (Base: March quarter 1982 = 100). See page 16 of Report 178 for the description and calculation of index, and page 24 of Report 178 for figures for 1982.

1983: January-March 111.2
April-June 111.9

[2]Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."
[3]For annual averages prior to 1978, April 1970 = 100.
[4]Previously known as the WHOLESALE PRICE INDEX, now the PRODUCER PRICE INDEX. The computation remains the same.
[5]Bulletin of Statistics, Department of Statistics, Pretoria.
[6]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.
[7]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

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REPUBLIC OF SOUTH AFRICA: MONTHLY FIGURES 1979-1982

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Consumer Price Index[2] (1975=100)	Producer Price Index All Groups (1975=100)	Total Employment in Mining and Quarrying (Code 35)[3]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[3]
Jan	1979	—	145.3	150.6	664,394	137,630
Feb	1979	—	146.1	152.1	680,054	136,252
Mar	1979	28.60	148.6	153.9	689,770	139,717
Apr	1979	—	149.9	155.3	682,505	143,812
May	1979	—	150.6	159.6	689,749	146,732
Jun	1979	29.44	152.4	163.1	692,209	152,862
Jul	1979	—	157.9	168.3	699,567	161,450
Aug	1979	—	160.2	171.4	692,377	159,514
Sep	1979	30.71	162.1	172.7	686,248	158,804
Oct	1979	—	162.9	174.5	692,859	162,721
Nov	1979	—	163.4	175.8	699,158	165,956
Dec	1979	31.89	164.0	176.8	697,741	165,182
Jan	1980	—	165.4	178.3	699,112	171,548
Feb	1980	—	167.0	180.5	705,758	165,790
Mar	1980	33.65	168.0	181.7	708,456	171,573
Apr	1980	—	170.0	184.2	710,652	169,415
May	1980	—	171.9	186.6	717,171	179,128
Jun	1980	34.48	174.6	189.0	714,379	183,739
Jul	1980	—	177.2	192.7	715,460	202,403
Aug	1980	—	179.2	196.8	716,486	206,514
Sep	1980	36.19	182.8	199.8	710,889	204,731
Oct	1980	—	186.3	203.1	720,246	204,602
Nov	1980	—	187.8	205.6	716,797	208,345
Dec	1980	37.69	189.9	206.5	705,087	211,829
Jan	1981	—	191.0	207.2	729,575	219,969
Feb	1981	—	193.8	209.8	725,647	210,275
Mar	1981	39.26	195.2	209.9	705,010	210,151
Apr	1981	—	196.4	211.6	719,674	217,124
May	1981	—	197.7	213.2	726,869	219,880
Jun	1981	40.41	200.0	215.3	728,506	237,049
Jul	1981	—	204.6	218.4	735,839	249,080
Aug	1981	—	208.0	222.6	722,684	245,817
Sep	1981	43.28	211.3	224.6	724,604	251,502
Oct	1981	—	213.4	227.0	717,918	248,159
Nov	1981	—	214.8	229.4	720,255	253,844
Dec	1981	44.52	216.3	230.4	709,612	257,655
Jan	1982	—	217.6	233.1	700,375	257,173
Feb	1982	—	210.2	236.8	705,992	250,190
Mar	1982	45.49	225.2	237.4	727,700	262,210
Apr	1982	—	228.9	241.9	707,502	252,562
May	1982	—	230.3	244.8	715,162	258,770
Jun	1982	45.77	232.1	246.7	707,552	261,361
Jul	1982	—	234.1	249.4	702,141	283,248
Aug	1982	—	236.8	253.4	705,562	276,730
Sep	1982	48.04	241.0	255.0	704,344	282,782
Oct	1982	—	243.9	260.1	701,316	285,328
Nov	1982	—	245.4	262.5	707,966	287,698
Dec	1982	49.61	246.2	263.0	683,982	288,019

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.
[2]Republic of South Africa Department of Statistics, Pretoria, "Government Gazette": Consumer Price Index for Urban Areas.
[3]Bulletin of Statistics, Department of Statistics, Pretoria.

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GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1] Industrial Commodities (1967=100)	Producer Price Index[1] All Commodities (1967=100)	Consumer Price Index[2] (1967=100)	GNP Implicit Price Deflator[3] (1972=100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4] Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1972 Avg.	117.9	119.1	125.3	100.00	4.56	4.59	4.26	3.71
1973 Avg.	125.9	134.7	133.1	105.75	4.84	4.98	4.51	3.91
1974 Avg.	153.8	160.1	147.7	115.08	5.44	5.63	4.88	4.21
1975 Avg.	171.5	174.9	161.2	125.79	6.13	6.24	5.39	4.64
1976 Avg.	182.4	183.0	170.5	132.34	6.76	6.87	5.91	4.96
1977 Avg.	195.1	194.2	181.5	140.05	7.28	7.67	6.43	5.39
1978 Avg.[5]	209.4	209.3	195.4	150.42	8.23	8.56	7.02	5.82
1979 Avg.	236.5	235.6	217.4	163.42	9.27	9.50	7.60	6.32
1980 Avg.	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
Oct 1982	314.3	299.8	294.1	—	12.51	13.26	10.22	8.41
Nov 1982	315.0	300.3	293.6	—	12.53	13.22	10.26	8.45
Dec 1982	315.2	300.7	292.4	210.00	12.53	13.05	10.32	8.51
Jan 1983	313.9	299.9	293.1	—	12.63	13.33	10.34	8.53
Feb 1983	313.9	300.9	293.2	—	12.66	13.29	10.41	8.56
Mar 1983	313.5	300.6	293.4	212.83	12.48	13.35	10.39	8.60
Apr 1983	312.4	300.6	295.5	—	12.67	13.34	10.43	8.60
May 1983	313.6	301.5	297.1	—	12.55	13.62	10.50	8.60
Jun 1983	315.3R	302.4R	298.1	214.55	12.66	13.38	10.52	8.63
Jul 1983	316.6	303.2	299.3	—	12.68	13.56	10.58	8.69
Aug 1983	317.5	304.9	300.3	—	12.63	13.46R	10.61R	8.64
Sep 1983	317.2	305.3	301.8	216.29R	12.71	13.47	10.69R	8.75R
Oct 1983	318.7P	306.3P	302.6P	—	12.77P	13.57P	10.78P	8.73P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.
[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.
[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.
[4]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." 2. All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.
[5]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

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UNITED STATES: MONTHLY FIGURES 1979-1982

	Producer Price Index[1] Industrial Commodities (1967=100)	Producer Price Index[1] All Commodities (1967=100)	Consumer Price Index[2] (1967=100)	GNP Implicit Price Deflator[3] (1972=100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4] Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electronic and Electronic Equipment (SIC 36)
Jan 1979	220.0	220.8	204.7	—	8.71	9.00	7.33	6.12
Feb 1979	222.5	224.1	207.1	—	8.81	9.01	7.33	6.14
Mar 1979	225.4	226.7	209.1	158.60	8.85	9.11	7.37	6.17
Apr 1979	229.0	230.0	211.5	—	9.03	9.49	7.52	6.12
May 1979	231.6	232.0	214.1	—	9.06	9.14	7.48	6.22
Jun 1979	234.0	233.5	216.6	161.85	9.09	9.44	7.54	6.26
Jul 1979	237.5	236.9	218.9	—	9.33	9.57	7.61	6.28
Aug 1979	240.6	238.3	221.1	—	9.39	9.70	7.66	6.36
Sep 1979	244.2	242.0	223.4	165.12	9.63	9.79	7.74	6.46
Oct 1979	249.0	245.6	225.4	—	9.67	9.87	7.83	6.48
Nov 1979	250.6	247.2	227.5	—	9.79	9.86	7.89	6.51
Dec 1979	253.1	249.7	229.9	168.05	9.81	9.92	7.93	6.63
Jan 1980	260.6	254.9	233.2	—	9.92	10.06	7.98	6.66
Feb 1980	265.9	260.2	236.4	—	9.93	10.02	8.01	6.70
Mar 1980	268.6	261.9	239.8	171.94	9.91	10.24	8.06	6.76
Apr 1980	271.3	262.8	242.5	—	10.01	10.31	8.13	6.78
May 1980	271.9	264.2	244.9	—	10.19	10.37	8.18	6.76
Jun 1980	273.5	265.6	247.6	176.46	10.13	10.70	8.25	6.85
Jul 1980	276.2	270.4	247.8	—	10.24	10.84	8.37	6.94
Aug 1980	278.2	273.8	249.4	—	10.38	10.80	8.40	6.99
Sep 1980	278.8	274.6	251.7	180.24	10.54	10.95	8.47	7.11
Oct 1980	282.0	277.8	253.9	—	10.58	11.01	8.53	7.16
Nov 1980	283.4	279.1	256.2	—	10.72	11.08	8.60	7.25
Dec 1980	286.6	280.8	258.4	185.13	10.83	11.33	8.69	7.35
Jan 1981	291.5	284.8	260.5	—	10.90	11.32	8.75	7.37
Feb 1981	295.7	287.6	263.2	—	11.13	11.36	8.80	7.40
Mar 1981	299.6	290.3	265.1	189.83	11.11	11.51	8.85	7.44
Apr 1981	303.5	293.4	266.8	—	11.28	11.64	8.95	7.47
May 1981	304.7	294.1	269.0	—	11.24	11.70	8.99	7.51
Jun 1981	305.1	294.8	271.3	192.56	11.29	11.90	9.06	7.57
Jul 1981	306.2	296.2	274.4	—	11.60	12.22	9.16	7.65
Aug 1981	307.2	296.4	276.5	—	11.84	12.12	9.18	7.74
Sep 1981	307.4	295.7	279.3	196.94	12.10	12.72	9.37	7.76
Oct 1981	309.0	296.1	279.9	—	12.08	12.45	9.36	7.82
Nov 1981	309.3	295.5	280.7	—	12.12	12.51	9.41	7.84
Dec 1981	310.0	295.8	281.5	201.22	12.07	12.48	9.51	7.92
Jan 1982	311.8	298.3	282.5	—	12.19	12.69	9.67	8.00
Feb 1982	311.6	298.6	283.4	—	12.22	12.64	9.67	7.98
Mar 1982	311.0	298.0	283.1	203.36	12.31	12.73	9.70	8.04
Apr 1982	309.9	298.0	284.3	—	12.26	12.72	9.79	8.07
May 1982	309.6	298.6	287.1	—	12.29	12.74	9.81	8.10
Jun 1982	310.6	299.3	290.6	206.15	12.28	12.95	9.94	8.14
Jul 1982	312.8	300.4	292.2	—	12.23	12.94	10.00	8.23
Aug 1982	313.2	300.2	292.8	—	12.29	13.01	10.01	8.30
Sep 1982	312.7	299.3	293.3	208.13	12.53	13.51	10.19	8.37
Oct 1982	314.3	299.8	294.1	—	12.51	13.26	10.22	8.41
Nov 1982	315.0	300.3	293.6	—	12.53	13.22	10.26	8.45
Dec 1982	315.2	300.7	292.4	210.00	12.53	13.05	10.32	8.51

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes").
[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.
[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.
[4]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual.

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REPRESENTATIVES AND CONSULTANTS

AUSTRALIA

Peter Stork
Oratom Consulting*
5 Gould Ave.
St. Ives
NSW 2075, Australia
Telephone: (61-2) 449-6783
Telex: 73303 (ORATOM AA)

JAPAN

Kazy Yokota
Japan Tech Services*
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 431-6025
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson
Southern Prospecting (Pty) Limited*
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Telephone: (27-11) 838-1868
Telex: 8-9878 SA

TAIWAN

Edward Bee
Bee & Liang Company, Limited*
8-G FL Jen AE Mansion
NOK 37 Jen AI Road Sec. 4
P.O. Box 1396
Taipei, Taiwan 106
Telephone: (886-2) 721-2117
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg*
83-A Hardee Lane
Whispering Pines, North Carolina 28327
Telephone: (919) 949-3622

Joe L. Hixon*
302 Lombardy
Sugarland, Texas 77478
Telephone: (713) 494-3802

W. Hardy Prentice*
11644 Harborview Drive
Cleveland, Ohio 44102
Telephone: (216) 631-2350

SPECIAL CONSULTANTS

James C.C. Stewart
London

Claus C. Thiesen
Kirkland, Washington

W. Bryan Webster
San Jose, California

T.C. Wu
Hong Kong

*Independent contractors representing Nuexco